BACKGROUND ON THE

DOE GROUNDWATER STRATEGY

A MANAGEMENT APPROACH TO THE GROUNDWATER ISSUE

CONSERVATION AND PROTECTION

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INTRODUCTION

The basic purpose of this document is to provide the background and rationale for the strategies recommended for adoption by DOE in implementing the Federal Water Policy on groundwater contamination. However, of necessity, it goes much further than that.

Contemporary thinking about the environment and about environmental issues, such as the concepts of "sustainable development", "integrated management" and "the ecosystem approach" dictate that no single environmental issue - such as groundwater contamination - can be addressed in isolation. Groundwater contamination cannot be addressed separately from the larger issue of groundwater management; groundwater concerns cannot be dealt with outside the context of the hydrologic cycle as a whole; the hydrologic cycle cannot be considered separately from the other physical, chemical and biological systems which together comprise the ecosystem in which we live.

Similarly, jurisdictional issues - such as what is "federal" and what is "provincial" - have become much less relevant as we have begun to realize that the consequences of any action taken by any segment, group or even individual members of society manifest themselves across all sectors and do not respect political boundaries. Thus, the use of (federally regulated) agricultural chemicals does not just affect the agricultural community; the impacts may be felt, (through contamination of provincially-managed groundwater) in the areas of human health, wildlife conservation, regional economic development, and so on. Federal regulations concerning fish habitat may have enormous impacts on the forestry and mining industries which are largely regulated by the provinces. Federal promotion of energy-saving technologies such as ground source heat pumps may significantly affect municipal water supplies - a provincial responsibility.

The need to deal with environmental problems in all their dimensions is daunting; indeed, it may never be possible to address such concerns in a truly

global way. Within the present structure of governments and government departments, it would be counterproductive to attempt to devise strategies which are too comprehensive in scope.

Nevertheless, in today's social climate it is mandatory to take as broad an approach as possible while keeping within the bounds of what is bureaucratically feasible.

The scope of this strategy has therefore been defined as follows:

- In terms of subject matter, it focusses on groundwater, and in particular on groundwater management.

- In terms of jurisdiction, it encompasses a cooperative federal/provincial, interdepartmental approach.

- In terms of societal concerns, it addresses environmental, social and economic issues.

At the same time, the groundwater strategy attempts to be consistent with overall federal and departmental policy directions and strategies in other areas, e.g., sustainable development, surface water, wildlife, wetlands conservation, economic development, etc. Undoubtedly, it will fail to do so in some areas, if only because federal and departmental legislation and policies are themselves inconsistent in many respects. This situation will no doubt be remedied in the course of time but it will be a long process. Environment Canada, however, cannot afford to wait any longer before implementing urgently needed groundwater strategies.

ACKNOWLEDGEMENTS

The need for DOE to "do something" about tackling the "groundwater issue" has been recognized for many years and many individuals within DOE have attempted to come to grips with the problem. This report is deeply indebted to those pioneers who wrestled with the issue at great length.

Many people have participated in the preparation of the present report by contributing ideas, comments, criticisms and advice. These contributions have been invaluable and are gratefully acknowledged.

THE PROBLEM

Groundwater Contamination - The Scope of the Problem

Groundwater concerns are emerging as one of the major environmental and health issues of the 1990's. Over 25% of Canadians depend directly on groundwater for their water supplies.[1] Because of this, and because all groundwater discharges ultimately into surface waters; wetlands, streams, rivers and lakes, the issue is broader than one of groundwater resources alone. Groundwater is an integral component of issues such as acid rain, waste disposal, the management of pesticides and other toxic chemicals, wetlands management and others. Incidents of groundwater contamination are increasing. This is a result of inappropriate site selection and use of materials and inadequate waste management practices by the industrial, municipal, agricultural and domestic sectors. The problem has been and is being compounded by past and present ignorance of the consequence of these practices. Preventive measures to forestall infiltration of toxic chemicals and other contaminants into the ground have been neglected. Groundwater is the major direct link to humans for a variety of hazardous wastes from such sources as abandoned industrial sites, toxic chemical and radioactive waste disposal sites, leaking underground storage tanks, spills and other accidents, the application of agricultural chemicals, etc.

Little has been done in Canada to document the real world impacts of groundwater contamination in objective terms. There are probably two main reasons why such socio-economic analyses have not been attempted;
1) groundwater is very much the "hidden resource"; the public cannot "see" the results of contaminated groundwater in the same way they can see dead fish on a beach or smell the effluent from a paper mill even though the impacts of contaminated groundwater may affect them just as badly or worse in the long run. 2) The full impacts of groundwater contamination may take decades or even longer to become apparent. Indeed, nothing at all may happen for many years after a groundwater contamination "incident" occurs.

A leaking underground storage tank may not affect a neighbouring water supply for years after the tank starts to leak, but when it does, it may be too late to do anything about it. Heavy metal leachates from mine tailings may not reach a salmon stream for a decade, but when they do that stream is written off for salmon spawning for a very long time, if not forever. It is, therefore, difficult to assess, at any given instant in time, just what the total impact of a contaminated aquifer is and will be, and to establish a realistic social and/or economic cost for that contamination, or conversely to place an economic value on preventing further contamination. Nevertheless, experience in Canada and in other countries, particularly the U.S., suggests that both the economic and social damages done by contaminated groundwater and the costs of cleaning it up are enormous. A sampling of the dollar figures applying to groundwater related concerns in various regions of Canada illustrates the magnitude of the issue. For example:

- Present estimates are that it will cost the Canadian economy 2.5 billion dollars to clean up known contaminated sites in Canada. It will cost the federal government 125 million dollars over the next five years to clean up federally owned and orphan sites alone.[2]

- The cost of cleaning up the Gloucester special waste site immediately adjacent to Ottawa International Airport will be at least 6 million dollars.[3]

- The cost of developing the proposed concept for disposing of high level nuclear wastes has been 400 million dollars since 1978. If a repository is actually built, it will cost 8 billion dollars (in 1989 dollars).[4]

- Between October 1987 and September 1988, 840 million dollars worth of pesticides of all types were sold for use in Canada.[5] The quantities of these pesticides and their metabolites reaching groundwater and their impacts are not known except in a very few site-specific cases.

- In 1988, 53 municipalities in New Brunswick were supplied by groundwater. If the groundwater supplying these communities were to become contaminated, it would cost 18.2 million dollars to provide an alternative water supply.[6]

- Provincial gross domestic product at market prices for P.E.I. for 1989 was 1.9 billion dollars (provisional figures).[7] P.E.I. is 88 per cent dependent on groundwater for all water uses.

- It will cost at least 100 million dollars to clean up the contamination in the ground at Pacific Place in Vancouver. Total costs for groundwater clean-up in the Fraser River are estimated to be between 220 million and 530 million dollars.[8]

- There are about twenty abandoned mine sites and twenty abandoned DEW-line sites in the N.W.T., all of which may contain toxic materials threatening the environment. To clean up and/or contain the wastes at these sites will cost several hundred million dollars.[9]

In all these examples, groundwater plays a major role, either by being a resource at risk itself or by acting as a major pathway by which other resources (e.g., surface water, wildlife) will be placed at risk.

By way of comparison:

- The Canadian share of the cost of the Great Lakes clean-up since 1972 has been about 2.8 billion dollars.[10]

- Between 1948 and 1990, the two senior levels of government in Canada have spent in excess of 2 billion dollars on major flood disasters and structural flood control projects. Since the inception of the federal-provincial Flood Damage Reduction Program in 1976, federal-provincial expenditures on and commitments to non structural measures (mapping, studies, forecasting) exceed 50 million dollars.[11]

These comparisons are, of course, very general and are presented primarily to demonstrate that groundwater contamination, in simple dollar terms alone, is comparable in magnitude and severity to other major water management issues which DOE has addressed in the past and is addressing nov.

Groundwater contamination is a problem that occurs nationwide, although different regions of Canada tend to have different kinds of problems.

It is a problem that threatens human health and the environment and has a major impact on the economic viability of large segments of Canadian industry.

Regardless of who is legally responsible for cleaning up specific cases of groundwater contamination, it is Canadian society as a whole which ultimately pays the price. This cost may manifest itself as increased health care costs, loss of environmental values, increased taxes, higher prices for goods and raw materials (including water) or investment opportunities forgone because the money has gone to cleaning up the results of past mistakes.

The clean-up costs we face at present are the result of past mistaken practices resulting from a completely inadequate valuation of the real worth of Canada's groundwater and other subsurface resources. Waste disposal has been very much a case of "out of sight, out of mind". Implicit in this approach is the arbitrary assignment of a value of zero to those resources which may be contaminated by the "disposed of" wastes. These grossly undervalued resources include not only the groundwater itself but also those surface waters into which the contaminated groundwater discharges and, indeed, the whole ecosystem of which the groundwater is a component.

It is not a problem that can be easily resolved. An incident occurring today, such as a spill, may have no apparent effect until decades later, by which time it is often too late to take effective remedial action. Sometimes, remedial technologies do not even exist. Contaminated groundwater under a leaking chemical dump may have very little effect on groundwater users but it may have an enormous impact on users of surface water if the contaminated groundwater reaches their source of supply (as has happened in the Great Lakes basin).

So far efforts to clean up groundwater contamination in both Canada and (particularly) the U.S. have for the most part been ineffective despite enormous expenditures of money and a strict and sometimes draconian legislative and regulatory approach.[12]

In Canada, attempts to deal with groundwater contamination have been hamstrung by a) the huge costs involved in clean-up, b) uncertainty as to what general approaches to adopt and c) probably most importantly, a lack of motivation to establish appropriate legislative, economic and other management instruments to manage efficiently a resource which has been tacitly assumed to have little economic or social value.

Even though the primary constitutional responsibility for groundwater (and indeed water resources in general) lies with the provinces, nevertheless, the Canadian public appears to believe that the federal government should be playing a major part in addressing the problems of groundwater contamination. Because groundwater contamination cannot be dealt with in isolation, the federal government will have to take on a more active role in groundwater development issues as well.

Groundwater Development Issues

Most public, media and government attention has been and still is focused on groundwater contamination, primarily because specific "disaster" related incidents are easy to focus on and on the face of it to understand. However, there is another much less known aspect to groundwater problems in Canada which is just as important and may be in the long run the true key to the long term protection of groundwater and associated ecosystems while deriving the best possible economic and social benefits from its use. This aspect relates to the development of groundwater and the subsurface as a resource in and of itself and includes issues relating to its use, its management and its development.

Focusing exclusively on the immediately obvious problems of groundwater contamination blinds us to the all important interconnection between groundwater and surface water.[13] It may not be immediately obvious that today's contaminated groundwater is tomorrow's contaminated surface water.

It seems to be more difficult for us to comprehend that today's baseflow is yesterday's groundwater and even more incomprehensible that this year's spring run-off could be next year's groundwater supply. Equally difficult to grasp is

the connection between wetlands and their role as, for some wetlands, groundwater recharge areas and, for others, sinks for pesticides and other agricultural chemicals. Yet all these relationships are implicit in the fundamental nature of the hydrologic cycle. Practically nothing has been done in Canada to investigate, let alone implement any of these "conjunctive use" kinds of approach from either a quality or a quantity-oriented perspective. Indeed, there is no incentive to investigate such methods designed to improve the efficiency of groundwater and surface water use, as long as the resource itself (the water) is considered to have little or no intrinsic value.

The hydrological cycle itself is only one component, albeit a fundamental one, of the even larger ecosystems which are vital to the sustainability and development of all human activities. If we do not manage our water resources properly, there is little hope that we will be able to manage our ecosystems effectively.

However, the signs are already here that we are going to have to take these options much more seriously in future. Some parts of the country are already facing water shortages (at present mainly in the Prairies); these problems are exacerbated by recurrent periods of drought and may become even worse under some climate change scenarios. As existing surface and groundwater supplies become contaminated from past practices, supplies will become even more scarce and impending shortages will spread to other parts of the country. If these regions are to continue to develop, all available options for assuring reliable water supplies will have to be thoroughly examined and a long term supply and demand management strategy developed and put in place.

There is yet another dimension to the groundwater issue, which goes essentially unnoticed amidst the contamination "catastrophes"; namely the use of the subsurface - the groundwater/aquifer system - as a resource in and of itself. Groundwater has been used for domestic and commercial cooling purposes for many years and the use of ground-source heat pumps is starting to increase significantly.[34]

In both these instances the thermal capacity of the groundwater/aquifer system is exploited to provide a competitive alternative to conventional energy

systems. Generally, the groundwater aspects of these activities are managed even less well than the more familiar groundwater resource and contamination problems.

All too frequently groundwater development and groundwater contamination are regarded and dealt with as if they were completely separate issues. Unfortunately, this categorization tends to obscure the fundamental fact that neither of these categories of issue can be dealt with independently of the other; it is not much use to anyone to have an essentially unlimited supply of groundwater if its quality is unsuitable (either because of its natural composition or because of anthropogenic contamination). Equally, pristine, super-clean groundwater is of very limited value if there is not enough of it to meet society's needs.

Appropriate legislative and regulatory frameworks and effective management tools, which by and large do not now exist will have to be established in order to manage both the quantity and quality aspects - primarily by the provinces.[14] The provinces will be looking to the federal government for knowledge and assistance in establishing these frameworks. Economic and other kinds of incentives need to be put in place to encourage the private sector to make wiser use of the country's groundwater resources. Traditionally, the federal government has played a major role in this area of activity. It is in the national interest that these developments occur in a timely and appropriate fashion in all areas of the country.

Background to Federal Involvement in Groundwater Issues

Until recently the federal government has tended to maintain a low profile in dealing with groundwater issues, restricting its activities to a modest research program.

There were many reasons for this relatively inactive (in comparison with surface water) role; a predominantly surface water oriented organization; a perception that the federal mandate for dealing with groundwater was

significantly weaker than that for surface water; an (apparent) lack of important groundwater related issues; a reluctance to take on responsibilities in a new area which would inevitably compete for resources with important traditional surface water programs; a critical shortage of qualified groundwater practitioners; a lack of any organized external (i.e., non-governmental) lobby for groundwater issues comparable to those for surface water issues.

However, in the last few years, it has become increasingly apparent that groundwater plays an important, and often all-important role in many environmental and surface water problems and the federal government (specifically DOE) has begun to recognize that its historical, minimalist approach to groundwater is no longer adequate to discharge its legitimate responsibilities. An important milestone in this process of awakening to the importance of groundwater to the department was the report of the Federal Water Inquiry[15] which recognized and emphasized the integrity of the hydrologic cycle and the interconnectedness of all its groundwater, surface water and atmospheric water components. Another was the Federal Water Policy,[16] which set forth a policy framework for groundwater which recognizes that the federal government does have well defined responsibilities for groundwater which it will discharge. The five elements of this policy framework make it clear that the government now considers that its mandate for engaging in groundwater related activities is very similar to its mandate for surface water.

Even more recently, the government announced its National Contaminated Sites Program,[2] whereby major federal funding will be made available to clean up contaminated sites. In the last three or four years, some DOE Regions have started to hire groundwater specialists to respond to the increasing demands for this kind of expertise.

The Federal Water Policy provides the basic directions for the federal government's groundwater programs. It expresses an explicit federal government commitment "to the preservation and enhancement of the groundwater resource for the beneficial use of present and future generations". A framework to guide the department in its program activities with respect to this commitment is part of the policy statement. It states that the federal government will:

- develop, with provincial governments and other interested parties, appropriate strategies, national guidelines and activities for groundwater assessment and protection (hereafter abbreviated to Strategy/Guideline Development);

- conduct research and undertake technological development and demonstration projects in response to groundwater problems (abbreviated to Research, Development and Demonstration);

- develop exemplary groundwater management practices involving federal lands, responsibilities, facilities, and federally funded projects (abbreviated to Manage Federal Responsibilities);

- develop measures to achieve appropriate groundwater quality in transboundary waters (abbreviated to Transboundary Water Quality); and

- provide information and advice on groundwater issues of federal and national interest (advice on Federal/National Issues).

POLICY AND STRATEGIC FRAMEWORK

Grand Strategy

The courses of action adopted by DOE for dealing with groundwater must be consistent with and an intimate part of its actions and policies for dealing with surface water issues, toxic chemicals and land use practices. They must:

- Simultaneously encompass both quantity and quality concerns;
- Emphasize prevention of future groundwater contamination in addition to fixing existing problems. Even though some existing contamination problems will have to be addressed because of overriding health or other concerns, these short-term issues must not override the longer term (and more crucial) concern with prevention;
- Provide for close, cooperative arrangements with the provinces and the private sector;
- Recognize the interconnectedness of all parts of the hydrologic cycle and of the ecosystems in which water plays a vital role;
- Recognize the legitimacy of the development-oriented mandates of other federal departments concerned with groundwater while stimulating their recognition of the importance of DOE's environmentally-oriented objectives; and
- Draw upon the capabilities of the academic and private sectors in achieving federal objectives while not impeding their capability to pursue their own goals.

The actions must be consistent with the policy directions established by the Federal Water Policy, other federal policies concerning issues such as Wetlands Conservation, the Inland Waters Directorate (IWD) Strategic Plan[29] and by the Green Plan exercise[17], which all fundamentally express the concept of "Sustainable Development".

Sustainable Development

There is more to the concept of sustainable development than merely preventing environmental damages which might be caused by whatever economic developments happen to come along. Implicit in the Brundtland[18] version of "Sustainable Development" are the dual imperatives: 1) developers must recognize the legitimacy of and give full attention to environmental concerns in their plans and projects, and 2) environmentalists must recognize the legitimacy of and give full attention to economic development concerns in their efforts to protect the environment.

This means that any organization subscribing to the principles of sustainable development, which DOE and the federal government have stated that they do has not only an obligation to protect the environment (including groundwater) from adverse impacts, but is also obliged to actively encourage environmentally compatible economic development.

Thus, DOE's groundwater strategy must provide for not only preserving and protecting groundwater against contamination but also for allowing the development of the most efficient and effective ways of using groundwater to achieve economic objectives.

Another important dimension to the sustainable development concern as it relates to groundwater is the extent to which groundwater is implicated in the sustainable development of other resources, such as wetlands. Traditionally, the primary concern with wetland conservation has been the preservation of wildlife habitat. However, more recently, the role of some wetlands as sources of groundwater recharge and, conversely, the role of groundwater discharge in maintaining other wetlands areas is beginning to be recognized, as is the place of wetlands in other water management issues.

DOE's groundwater strategy must recognize this and other, similar sustainable development concerns.

Groundwater Protection

In its most elementary form, "Sustainable Development of Groundwater" could be interpreted to mean that aquifers may be developed up to, but not beyond the point where the amount of groundwater extracted equalled the amount recharged by natural or artificial means.* This could be termed the "No Groundwater Mining" strategy.

However, in many parts of Canada before extraction rates reached this point, deterioration in water quality would set in caused by intrusion of poorer quality water from underlying brackish or saline groundwater, by sea water intrusion, by induced infiltration of contaminated surface or soil waters or other causes. However, such contamination can usually be prevented, or at least confined to acceptable levels, by appropriate well field design and pumping schedules and a sound aquifer management plan, provided that an adequate initial aquifer evaluation has been carried out. Nevertheless, extraction rates would generally be lower than for the "No Groundwater Mining" option. This second option could be called the "Quality Limited Development" strategy.

In Canada, both of the foregoing strategies could be and have been implemented by a single water management agency, that is to say the particular (usually provincial) organization charged with groundwater management. Fifteen or twenty years ago, this was all it took to ensure a continuing supply of good quality groundwater (or so it seemed). It did not present a very formidable challenge and there was little need for the federal government to become involved.

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* For a comprehensive discussion of aquifer and basin yields see Freeze and Cherry, chapter 8.[19]

Today, however, the most serious threats to sustaining a continuing supply of good quality groundwater are now seen to arise from activities partially or completely out of the control of the specific agency (provincial or other) concerned with groundwater management. For example, groundwater supplies can be threatened by improper application of fertilizers or pesticides (in which provincial and federal agriculture departments have jurisdiction), by spills of chemicals from road and rail transportation systems (once again, falling under the jurisdiction of various federal and provincial ministries), by improperly planned or malfunctioning sewage disposal systems (again, various provincial and federal agencies have jurisdiction over different aspects), by activities such as the installation of ground based heat pump energy systems or by mining or oil exploration activities, by leaks from underground fuel storage tanks, spills of contaminants from industrial activities and improper disposal of hazardous wastes on landfills, etc. These diverse activities involve many other federal, provincial and municipal departments. If aquifers in use as water supplies are to be adequately protected, all these organizations must subscribe to mutually agreed upon policies for aquifer protection. Clearly, a high degree of both intra- and inter-governmental coordination is essential. No one agency can possibly do an effective job on its own. When the scope of the scenario is expanded to include the prevention of surface water contamination by contaminated groundwater and the protection of ecosystems the situation becomes even more complex.

Whereas the provinces and local authorities undoubtedly have the major role in developing, putting into place and implementing the appropriate legislative and regulatory mechanisms to provide for groundwater protection, there are several areas where the federal government can and should play an important role.

In broad terms, these are the five elements of the Federal Water Policy relating to groundwater as stated on page 12.

The actual mechanisms for implementing this groundwater protection strategy, such as cost-shared agreements with the provinces, providing economic incentives, etc. will be discussed later.

However, another and perhaps the most important part that DOE should play, is a coordinating role whereby the various federal departments involved in

groundwater activities act in concert and in agreement with the defined federal policy framework.

Groundwater Development

Canada is blessed with an abundance of fresh water relative to its population.[20] The country's rivers contain 9 per cent of the world's fresh water annual flow yet the population is about one half per cent of the world's population. Even when the concentration of population in the south is taken into consideration, Canada still enjoys a relative abundance of fresh surface water supplies compared with most other countries. While Canada has certainly benefited greatly from its generous natural endowment with fresh water, there have been some drawbacks, which are only now becoming apparent.

Because supplies have been relatively abundant, water resource management has tended to focus on the extraction and distribution of an apparently unlimited water supply rather than on the allocation of a finite supply of a (relatively) scarce resource.

There has been little need to address issues such as allocation between competing users (including the ecosystem), managing supplies for optimal economic and environmental benefits, protection of supplies from contamination or other damage and so on.

In other words, because water has been so abundant, we have tended to treat it as a free good, i.e., as if it had no intrinsic value. There is no benefit or motivation to develop sound management practices and policies for something that has no value. The consequence is that today, when fresh water supplies of all kinds are becoming less abundant (relative to demand) due to increasing demands, contamination, projected climate change scenarios and so on, the management tools required to deal with the problems of limited supply, such as allocation, economic instruments such as water pricing, resource protection, optimizing development of supplies, etc. have not been developed.

This problem is not unique to groundwater; surface water management suffers in a similar way. However, surface water managers are somewhat better off in that

generally speaking, the resource has been reasonably well inventoried and evaluated, some legislation and regulations have been established, some procedures do exist for water rights allocation, etc.

The field of groundwater management is much less well developed in all respects. Not only is the overall level of groundwater management less well developed than for surface water, but the variability of management capability from province to province is also much greater. However, it is fair to state that on a national basis significant deficiencies exist in the following areas of groundwater management:

1. Resource evaluation - i.e., aquifer identification and assessment.

2. Aquifer management - planning and operations.

3. Groundwater allocation - licensing and regulating withdrawals.

4. Conjunctive surface and groundwater planning and operations, e.g., planning and development of artificial recharge projects.

As with groundwater contamination, the major responsibility for actually carrying out each of these areas of groundwater management lies with the provinces. Also, many of these activities overlap with the actions required to put into practice an effective groundwater contamination strategy, e.g., it is clearly impossible to protect an aquifer from contamination if it has not been delineated and its characteristics determined. As with contamination, the DOE role in groundwater development is to provide guidelines and leadership, perform R, D and D, discharge federal responsibilities, take care of transboundary concerns and provide advice as well as to coordinate the federal position.

Economics of Groundwater Contamination

The estimated costs of cleaning up groundwater contamination and the significance of groundwater to the economy given on pages 5 to 6 are only a sampling of the total costs that could be incurred if every actual or potential case of groundwater contamination were to be cleaned up or avoided. This total would be, at the very least, several billion dollars.

This cost, if incurred, would impose an enormous burden on both national and regional economies with critical implications for Canada's international competitiveness, its capability to attract foreign investment, its citizens' quality of life and so on. There are also growing doubts as to whether existing technology is capable of cleaning up many contaminated sites.[12] Therefore, it would seem to be only elementary common-sense to ask whether or not all such expenditures are really necessary. In other words, what are the net benefits of preventing future groundwater contamination? What are the net benefits of cleaning up (or not cleaning up) existing groundwater contamination? Because of the staggering dollar costs, it is surprising that so little has been done to address these questions. At present, decisions to clean up or to protect the environment from groundwater contamination seem to be based almost entirely on subjective evaluations of what problems should be tackled and which postponed or left alone. Certainly, most efforts (and resources) are dedicated to remediation and are reactive as opposed to preventive.

A major problem which has contributed to this lack of action on the economic side of the issue is that it is technically difficult to assess the real costs to society of contaminating something (i.e., groundwater and other water) which traditionally has been assumed to have no value. A recent UN sponsored conference in Spain dealt with some of these problems.[42]

One approach which has been proposed is to regard the "cost" of contaminating an aquifer in use as a water supply as being the cost of developing an alternative water supply. However, this approach presents a number of problems e.g. it neglects opportunity costs (what could have been done with the money if it had not been spent on developing an alternative supply) and discounts the benefits that might have arisen from future development of an aquifer which is not already being used to full capacity.

These difficulties are not easy to resolve, primarily because the water in the aquifer is (tacitly) assumed to have no value in and of itself.

Therefore, a necessary precondition to making realistic assessments of what the costs of existing contaminated groundwater are and what the benefits are in

preventing future contamination is an assessment of the value of uncontaminated ground (and surface) water. Such an assessment is not a trivial undertaking. For example, a recent national survey of the value of wildlife to Canadians[43] cost about $500,000.

INSTRUMENTS AND ACTORS

Economic Instruments

Because direct responsibility for the day to day management of groundwater lies (for the most part) with the provinces, federal objectives can best be achieved by indirect means. One of the most effective tools in water management programs has been the use of economic instruments of various kinds. This approach has been used with great success in past water management programs, notably the River Basin Planning Program[21] and the Flood Damage Reduction Program.[22]

Some of these economic instruments are:

1) Provide federal financial support only in areas or on practices that meet specific criteria designed to promote rational groundwater management. Possible applications in the groundwater area could include:

   a) Granting of mortgages to developments only in areas where no significant groundwater contamination hazard existed.

      Such a policy would imply the existence of a groundwater contamination hazard map for the area concerned. Provinces could be encouraged to develop such maps through cost shared federal-provincial agreements.

   b) Subsidize only those new technological developments which meet accepted national standards. An example of this approach might be a granting of federal subsidies to ground-source heat pump developments only if the ground system installation techniques complied with established well construction standards. This implies the existence of such standards on a national scale.

      Some provinces nov have some regulations and standards for well construction, completion etc., but others do not. Where such standards

did not exist, provinces could be encouraged to develop them through cost shared federal-provincial agreements.

c) Purchasing property or constructing buildings and other works only in those areas where no significant groundwater hazard existed. This situation is similar to a) only it implies not developing federal facilities in areas susceptible to groundwater contamination, rather than withholding mortgage money.

2) Encouraging projects and practices which would tend to decrease the risk of groundwater contamination or otherwise encourage the wise use of groundwater by providing low cost loans, grants or other subsidies to such projects and practices.

Falling into this category would be the recently announced National Contaminated Sites Program[2] where the federal government offers to pay 50 per cent of the cost of cleaning up contaminated sites, provided the provinces take steps to clean up non-orphan sites.

National Guidelines, Objectives, Standards

There are many different kinds of groundwater related issues, activities and procedures to which some kind of national guidelines or standards could be applied.

Some of the groundwater-related topics for which such guidelines have been proposed recently include:

1. Guidelines for deep-well disposal of liquid wastes.

2. Standard practices for groundwater well and test-hole abandonment.

3. Codes of practices for water well drilling, construction and testing.

4. Standards of Training and Apprenticeship for Well Drillers.

5. Standard procedures for Groundwater Sampling and Chemical Analysis.

6. National Standards for Exchange of Hydrogeological Data.

7. Minimal National Standards for Aquifer Protection.

8. Hydrogeologic Guidelines and Standards for Landfill Siting, Construction and Operation.

9. Clean-up Criteria for Orphan Sites (under development).

10. Criteria for Selecting Sites for Clean-up (under development).

11. Manual of Procedures for Monitoring Waste Sites (under development).

Undoubtedly there are many other topics to which national standards and guidelines could be applied appropriately; for example, regarding the groundwater aspects of managing wetlands and the conduct of environmental assessments.

The list above demonstrates the wide variety of topics which at least some people consider appropriate for the setting of national guidelines. Some are primarily technological (e.g., those dealing with well drilling practice); some are primarily scientific (e.g., those dealing with sampling and analytical procedures); others are geotechnical/engineering in nature (e.g., those relating to siting and construction of landfills); yet others involve a high degree of hydrogeologic expertise (e.g., minimum standards for aquifer protection); some involve a combination of scientific/engineering and socio-economic considerations (e.g., criteria for deep well disposal, criteria for orphan site clean-up selection) and so on.

Many of these topics deal with matters where the provinces have the primary jurisdiction. However, the job of the provinces in developing, enacting and enforcing regulations and legislation would be made much easier if national guidelines existed, to which provincial regulations could be related. These national guidelines, then, although carrying no legal authority, are perceived

as having considerable moral authority and influence. This is especially true if the guidelines have been developed by joint federal/provincial agreement with input from the appropriate private sector, academic and public interest groups.

The important thing from the provincial point of view appears to be that National Guidelines do not restrict the freedom of the provinces to act in their own best interests, as they see it, while at the same time provide them with a nationally agreed-on yard-stick by which their own regulatory and legislative actions can be judged. Because of the complexity of groundwater issues, considerable technical and engineering flexibility is needed in implementing any national guideline at a regional, provincial or local level. In other words, National Guidelines say, in effect: "These guidelines represent the national Canadian consensus on how this particular activity can be carried out most effectively in all parts of the country." The provincial regulations regulating the same activity then say: "This is how we (the responsible provincial agency) direct that this particular activity should be carried out, bearing in mind the national consensus on how it should be done, as modified in the light of local conditions."

This kind of approach has worked well in other areas of water resources e.g., Water Quality Guidelines,[23] and there is every reason to believe it would work well for groundwater activities as well.

Groundwater Modelling and Data Acquisition

As in any other field of study in the hydrologic sciences, groundwater practitioners make wide use of a variety of mathematical models. Such models are used for example, to gain a better understanding of physical/chemical processes occuring in an aquifer, to evaluate yields from an aquifer, to forecast the development of contaminant plumes and so on.

In the past, the major constraint on the application of such models was the availability of computing power. Twenty or even ten years ago the speed and storage capacity of the then available computers was such that only relatively

straightforward situations could be modelled realistically at a reasonable cost.

However, since that time, the storage capacity, speed and cost of computer hardware have improved so much, that computational hardware and software limitations are no longer the major constraint to the further development and utilisation of mathematical groundwater models.

Today, the major constraint to the use of mathematical models is the availability of input data, which are essential to the realistic functioning of such models. Such data include the physical characteristics of the aquifer, e.g., permeability, porosity, anisotropy, storage co-efficient, compressibility of the aquifer, geometry and physical dimensions of fractures; the chemistry of the system, e.g., mineralogy of the aquifer, chemistry of the groundwater, nature of any dissolved gases, presence or absence of immiscible fluids, dispersivity, partition coefficients, and so on.

To collect such data (all of which and more are needed for a typical groundwater contamination problem) for even a small aquifer at a sufficiently fine scale to obtain reliable results is an extremely expensive process. (This is one of the main reasons why groundwater contamination clean-up projects are so costly).

Short of a major breakthrough in our comprehension of the physical and chemical processes occurring in aquifers, this situation seems likely to continue for the foreseeable future.

On the other hand, the data required for day to day management purposes, e.g., advising drillers on site selection, issuing licenses to withdraw groundwater, etc., are by and large far less complex and much less expensive.

A large part of this kind of data is the water well records submitted by the well drillers. Many observation well hydrograph records and chemical analyses are paid for by the organization pumping the groundwater, e.g., a municipality.

The implications of the foregoing for groundwater data collection programs are:

a) All groundwater data collection programs ("monitoring") must be designed to serve well-defined project-specific purposes. For example, an observation well or piezometer designed to measure water levels could be (and often is) installed to measure the response of an aquifer to pumping. Such a well might also be installed to measure the natural fluctuations in an aquifer which had the potential to be developed for water-supply purposes or as a part of an integrated data network for assessing the hydrologic impacts of climatic change. However, a national (or regional) groundwater observation well network to serve some general purpose such as "establishing the state of the groundwater resource in Canada" is virtually impossible to justify on economic grounds.

In a contamination investigation, an extremely dense "network" of piezometers, wells, sampling points is often essential to define the extent of the contamination and to develop schemes for remediation.[31] These very high cost data acquisition programs should be justified by the social and economic implications of the problem under investigation and they often are. (However, in some situations the costs of investigating a given groundwater contamination issue may just not be warranted by the potential benefits). Other viable groundwater quality monitoring programs could include, for example, networks to monitor the impacts of acid rain on groundwater, or to monitor the (hoped for) decrease in pesticide levels in groundwater after use of a pesticide has been terminated or modified (e.g. aldicarb in PEI groundwater). However, as with groundwater levels, national or regional groundwater quality networks would be very difficult to justify economically.

b) Traditional "monitoring" programs analogous to surface water programs designed to provide early warning of potential problems have limited utility from a groundwater perspective. One problem, common to both groundwater and surface water is that, although we may have a general idea about what chemicals to look for, it is impossible to know beforehand exactly what the contaminants of concern will be ten or fifteen years in the future, and hence what to monitor for now.

The second, and much more important from the point of view of groundwater, is that by the time a monitoring network detects the appearance of a contaminant in the groundwater it is often too late to do anything about it. This is due to the relatively low velocities of flow of most groundwaters and to the uncertainties in flow directions which are a consequence of the three-dimensional nature of groundwater flow systems. By the time the contamination is detected, large parts of the aquifer have often already become contaminated.

c) There is a strong incentive to develop new methodologies to replace and supplement traditional "monitoring" techniques. For example, drawing on pesticide sales figures, geological information, crop types, etc. and combining these types of data into a "probability of groundwater contamination" map using a Geographic Information System (GIS)[32] of some kind shows considerable promise as a low cost alternative to installing an extensive and expensive network of observation wells.

d) Data storage and processing systems for groundwater data will have to be capable of dealing with the specific problems peculiar to groundwater. Adaptation of existing surface-water oriented systems wholesale will not necessarily work for groundwater.

e) Although many groundwater contamination programs are severely constrained by the costs of data acquisition, groundwater management programs need not suffer to anything like the same extent. (This is one of the reasons why <u>prevention of contamination by good management is preferable</u> to attempting to cure the problem afterwards).

Groundwater Inventories and Data Banks

A recent federal/provincial workshop on groundwater data banks[24] concluded that the most significant impediments to sound groundwater management are:

- the lack of coherent and/or consistent groundwater management strategies and policies at all levels of government;

- the lack of an organized framework of knowledge of the groundwater resource in all jurisdictions across the country; and

- the lack of organized groundwater data bases focusing on groundwater management needs..

These problems derive from (at least in part) and are compounded by the division of groundwater responsibilities in all jurisdictions into an environmental protection component and a resource component.

It also was evident at the workshop that the agencies holding the groundwater data are overwhelmingly the resource-development agencies; environmental protection agencies appear to have essentially no groundwater data or information bases.

It is, therefore, not surprising that governments are finding it very difficult to develop coherent strategies for any kind of groundwater management, whether it be aquifer protection, allocation of water rights or anything else.

However, there are ways to address the three impediments mentioned above.

A major accomplishment of the recent Workshop was the recognition that groundwater data programs must be designed to meet the needs of a well thought out groundwater management strategy. Unless this linkage is made, groundwater data collection and management programs (like any other data programs) quickly degenerate into data collection for its own sake.

Therefore all three of the impediments mentioned must be addressed together and be mutually supportive and consistent.

One approach which the department has used very successfully in other water management issues (such as River Basin Planning and Flood Damage Reduction) is to enter into cost-shared agreements with the provinces. For groundwater data and information the approach would involve:

1. Entering into cost-shared agreements with the provinces to develop nationally compatible groundwater data banks.

2. Concurrent with 1 to enter into cost-shared agreements to develop an inventory of groundwater resources across the country, to some minimum scale of detail and to minimum national standards.

3. To make federal financial contributions to 1 and 2 above conditional on provinces developing rational groundwater management strategies. At a minimum these strategies would have to provide for aquifer protection as well as development.

It is believed that at a technical level a large majority of provinces would be supportive of this kind of approach.

From the departmental perspective this approach has the basic merit that it avoids the danger of getting into the groundwater data collection business, which would be very expensive. In fact, there already exists a large quantity of raw groundwater data in most jurisdictions. The problem is not inadequate data (or if it is, that is not now apparent), but rather inadequately organized data.

Mechanisms such as the Canada Water Act (CWA) already exist whereby such agreements could be put in place so that bureaucratic problems would be minimized. Presumably any future legislation which might replace the CWA would contain similar provisions.

Environmental Assessments and Emergency Planning.

It is axiomatic, in managing any environmental resource, and especially groundwater, that it is much more efficient and far less costly to prevent damage from happening in the first place than to fix it up afterwards. Some of the more effective non-economics oriented tools for preventing the occurrence of groundwater contamination are (i) the assessment of the impacts of projects before they are put in place, (ii) responding promptly

to accidents such as spills or other environmental emergencies so that action can be taken to deal with the situation before significant damage has been done and (iii) adopting state of the art technologies and management practices to prevent spills and losses from industrial and transportation sources. Together, these tools can be considered under two headings:

(a) **Environmental Assessments**

Some of the ways in which groundwater can be implicated in the impacts of projects are mentioned throughout this report. They include the impacts of mining on fish habitat (through the leaching of toxic contaminants from tailings piles or acid mine drainage); contamination of drinking water supplies by agricultural practices (e.g., by excessive application of poultry wastes as fertilizers, by improper use of pesticides) or improper industrial waste disposal practices (examples are legion); and in many other ways.

Detailed descriptions of the ways in which groundwater can become contaminated and its impacts on the environment and human activities can be found in standard groundwater texts such as Freeze and Cherry[19] and are summarized in DOE Fact Sheet No. 5 - Groundwater - Nature's Hidden Treasure[44].

Almost any conceivable land-based development has the potential to cause or to be affected by groundwater contamination. Therefore groundwater must be considered an essential and integral part of any environmental assessment. However, it is all too frequently the case that groundwater concerns are not given appropriate consideration in such assessments, with the inevitable "unexpected" consequences of greater or lesser severity.

Perhaps the most obvious examples of this lack of attention to the groundwater aspects of developments are the many landfills which have been sited in abandoned gravel pits; it really should not surprise anyone that such landfills tend to leak severely.

(b) **Emergency Planning**

Emergency planning is analogous to environmental assessment in that it attempts to foresee the consequences of possible future events, and to minimize the adverse environmental impacts of such events, in this case

by making contingency plans for responding to a variety of hypothetical emergency scenarios such as spills, accidents, etc. From the groundwater point of view, the most significant kinds of emergency are spills of hazardous products from industrial facilities, such as spills of wood preservatives from lumber yards, or accidents on transportation routes involving the release of hazardous materials such as railroad accidents in which organic solvents or other materials may be released from damaged cars.

It is stating no more than the obvious to say that the subsurface environment is one of the most vulnerable components of the environment to such land-based accidents. However, it is unfortunately also the case that groundwater is often overlooked by those responsible for dealing with such accidents. This situation is especially regrettable because often, if action is taken promptly, the groundwater system can be preserved, essentially undamaged, whereas if action is delayed for even a short time, irreversible harm to the system can result.

The reason why groundwater concerns have been too often overlooked in both these areas is almost certainly a lack of trained personnel in governments, both federal and provincial and in industry, as well as the "out of sight, out of mind" approach.

In view of the critical shortage of hydrogeologic expertise discussed elsewhere in this report, there are no easy solutions. For the short term the most feasible solution appears to lie in training existing personnel, while taking steps to encourage the education system to train more groundwater professionals for the long term.

Avareness of Groundwater

There is a strong and widespread feeling among groundwater program managers and workers in federal and provincial governments that both the public and political and public service decision makers are seriously uninformed about the importance of groundwater as a resource and as a critical component of many environmental issues.

One problem is that groundwater is very much the "invisible resource" so that the "out-of-sight, out-of-mind" mindset seems to dominate.[30]

Mechanisms for remedying this situation include:

- Newsletters targeted to a variety of audiences.
- Information guides, fact sheets, brochures.
- Displays for various audiences.
- Public "events", such as Environment Week.
- Articles in newspapers.
- Media interviews.
- Movies/videotapes for various audiences.
- Lectures and seminars at colleges and schools.
- Advertising government services in, for example, the Yellow Pages.

Most of these relate to audiences outside the government sector. How to get the "message" to politicians and public service managers is much more difficult. This particular group is highly influenced by the media and media attention tends to focus on "environmental disasters" which make for good copy but also by their very nature tend to be short term. This kind of media treatment serves very well to raise public and political consciousness about the environment in general and specific disasters in particular (e.g., Ste Basile-Le-Grand, Hagarsville) but it has at least two serious shortcomings from the groundwater point of view.

One is that media-type national disasters tend not to happen to groundwater or, to put it another way, no-one can see groundwater disasters when they happen because they happen underground. The other drawback is that the media's

environmental disaster approach tends to generate a short-term, crisis-response approach to environment management by governments. This reactive crisis-response approach is the least effective way of dealing with most groundwater problems. By focusing on the short term, governments tend to neglect the longer term, preventive strategies that are in the long run much more effective in dealing with groundwater management issues.

Somehov, communications mechanisms must be developed to persuade politicians and public service managers to pay less attention to crises and more to long term management.

The Respective Roles of the Federal and Provincial Governments

Throughout this report, as in real life, there are three underlying themes:

- the provinces have the major legislative/constitutional responsibility for water, including groundwater;

- a host of activities undertaken by or under the jurisdiction of the federal government, as well as by the provincial governments have a major influence on groundwater; and

- groundwater can and does have a significant impact on activities that do fall under the jurisdiction of the federal government.

In the past, before these three realities were understood, there were endless discussions as to whether the federal government had the constitutional authority to deal with groundwater and whether or not it should have a "groundwater program."

Today, these arguments seem sterile and futile. Many of the actions taken by the federal government have a significant effect on groundwater and on the way the provinces manage it. Many of the problems facing the federal government and which are undoubtedly its responsibility have a very significant groundwater component. Therefore, the federal government is involved in

groundwater management, regardless of constitutional authority and regardless of whether it wants to be or not.

The latest development, the rapidly escalating costs of cleaning up groundwater contamination is only a dramatic demonstration of the truism of the modern world that everything depends on everything else. If the known instances of groundwater contamination were to be cleaned up, the economy of the whole country would be severely affected regardless of who actually paid for the clean-up.

Some people seem to believe that because provincial governments have the primary legislative authority for groundwater, there is not much the federal government can do short of declaring a national emergency and assuming over-riding powers. This attitude reflects:

- a misplaced faith that legislation and regulation alone can and will cure the problem; and

- an unfamiliarity with the many non-legislative, non-regulatory instruments that the federal government has at its disposal to achieve its purposes and which it has used many times in just this way to great effect. Some of these instruments are discussed elsewhere in this report.

The fact of the matter is that the federal government can have an enormous influence on the way groundwater is managed in Canada, without trespassing one millimetre into areas of provincial responsibility. The Federal Water Inquiry[15] made the point that the public was not interested in what level of government did what; what the public wants is effective action.

Therefore there is no reason why the federal and provincial governments, exerting their own mandates, cannot work together in harmony to put the country's groundwater management on a sound footing.

Accordingly there is no reason to seek to change the relative roles of the federal and provincial governments; there is no need for increased authority to do the things that need to be done and, especially, no reason to place the

blame for lack of action on many of the more important issues on uncertain constitutional authorities. Between them, the federal and provincial governments have all the authority they need, right now. What is required is to harmonize our approaches, so that we act and are seen to act in concert.

The need for the federal and provincial governments to act in concert to address important environmental issues has been explicitly recognized in a Statement of Interjurisdictional Cooperation on Environmental Matters issued by the Canadian Council of Ministers of the Environment in March 1990.[33]

Even in cases where there appears to be a major legislative or regulatory deficiency, the federal government should be cautious about rushing in to fill the gap with its own legislation or regulations. It may well be that it will be far more efficient to encourage the provinces to do so. For instance, one major deficiency in preventing groundwater contamination is inadequate land use planning and regulation. As the provinces have most of the constitutional authority for land use management, it will be much more efficient for the federal government to look for the most effective incentives to persuade the provinces to introduce appropriate land-use regulations than to attempt to bring in its own legislation.

Role of other Federal Departments

Many federal government departments have mandates for activities which can have a very important impact on groundwater. Many other departments have responsibilities for activities which depend on or can be severely affected by groundwater.

A list of the more important departments (in terms of their influence on or potential to be influenced by groundwater) would have to include:

Agriculture which regulates pesticides and is concerned with other agricultural chemicals which can contaminate groundwater. It is also concerned with water supply in the west, where groundwater is very important. The very nature of agriculture means that Agriculture Canada has to be considered a major federal player in the groundwater game.

Energy, Mines and Resources (EMR) which, like Agriculture, has fundamental ties to groundwater because of its basic interest in the subsurface environment. Many geotechnical questions of interest to EMR have a strong groundwater component and there are fundamental scientific similarities between the role of groundwater and groundwater processes and ore genesis, oil occurrence, exploration and production, mine waste disposal, permafrost, geothermal energy and so on. EMR has to be considered another major actor in the groundwater field.

Transport (DOT) regulates and controls many activities which can have a very large impact on groundwater. Transport is the operator of airport facilities which, being large enterprises situated in proximity to large population centres have the potential to cause serious groundwater contamination problems e.g., from airplane deicing or firefighting training. Transport also controls federal transportation routes such as highways, rivers and railways on which the risk of accidents and spills is higher with attendant dangers to groundwater.

Health and Welfare (DHW) is concerned with drinking water and its sources and is therefore very concerned by perceived threats to water supplies for humans. NHW has carried out a number of studies on groundwater as it relates to health.

Fisheries and Oceans (DFO) has a major interest in various kinds of development which can impact fish and fish habitat. On the west coast, one of the major threats to the salmon fishery is the many mining developments with associated tailings and waste rock piles.

Contaminated groundwater from these wastes can be a major threat to the salmon streams. DFO is also interested in the use of and further development of groundwater supplies for fish hatcheries, to which groundwater is particularly suited.

Indian Affairs and Northern Development (DIAND), together with the Territorial governments has the responsibility for managing water, including groundwater in the two Territories of Canada.

Many other departments have responsibilities that are somewhat more remote, but nevertheless can have significant impacts on groundwater e.g. Central Mortgage and Housing Corporation (CMHC) with its influence on land use; Defence (DND), which is a large federal land owner and a major user of petroleum fuels, Public Works (DPW), which owns and manages much federal property and so on.

Crown Corporations can have a very important interest in and impact on groundwater. For example, Atomic Energy of Canada Limited (AECL) has spent 400 million dollars in the last twelve years in developing its concept for the disposal of high level nuclear wastes in which groundwater is probably the most significant factor.

A recurrent topic for discussion over the years has been the extent to which other federal departments should be expected to conduct their own groundwater-related affairs and the extent to which DOE, as the principal federal water department should advise or provide assistance in other ways. There appear to be no general answers which are applicable to all departments for all time.

In some situations it clearly makes sense for the other federal department to acquire its own groundwater expertise to run its own programs. This is what Agriculture Canada has done with Prairie Farm Rehabilitation Administration (PFRA) and its groundwater supply programs on the Prairies.

These programs require large enough resources (py and $) that no other agency can provide them as a service, so that there is really no alternative other than to establish a special program within PFRA to do the job.

Fisheries and Oceans would probably find it uneconomical to establish its own unit to look after finding groundwater supplies for fish hatcheries. In situations like these, the Departments concerned have often approached DOE for assistance. DOE's response has varied from time to time and from Region to Region. In some cases DOE has conducted significant field and other studies for the requesting Department, in others it has provided advice and in yet others the request for help has been turned down flat.

At a corporate level, DOE has signed memoranda of agreement with other federal agencies agreeing to take care of certain parts of particular issues. For instance, in 1981 DOE and the Atomic Energy Control Board (AECB) signed an agreement[40] whereby DOE undertook to look after the environmental aspects of issues in the nuclear field, including groundwater.

Today, the question of how to respond to other departments' requests for groundwater assistance is even more uncertain. Under current resource constraints, it is difficult to see how DOE can respond positively to all requests for advice from other departments. Yet the Federal Water Policy states that the federal government will provide advice.

At the same time both DOE and other federal departments are facing increasing demands for environmental expertise, especially for groundwater, due to requirements of new legislation such as the Canadian Environmental Protection Act (CEPA), especially Part IV of that Act, and the recently introduced legislation on environmental assessment[41]. It is no more than a fact that any release of a non-volatile regulated substance on the land surface (whether accidental or deliberate) will in almost all circumstances impact the subsurface before anything else.

What happens to that substance subsequently will be largely determined by its interaction with the materials in the subsurface, i.e. the groundwater/aquifer system. Therefore, all departments will require significant new groundwater capabilities - whether this be accomplished by hiring full time staff or through contracts with the private sector. Whether DOE, with its role as the enforcer of CEPA Part IV, could or should assist other departments to fulfil their obligations under CEPA is uncertain.

It may be that this problem is only temporary and that its cause is that DOE (and other departments) have not yet had time to respond to the relatively recent announcement of the Federal Water Policy and the enactment of CEPA. In fact, some DOE Regions (notably WNR and PYR) have recently staffed more groundwater positions.

However, even if other Regions follow suit, the problem remains that the Department does not have a policy regarding how it should respond to requests for help from other departments. There is more to this than whether or not DOE should "do their job for them."

If DOE turns other departments away, it will have no influence on how the other department handles its groundwater programs and there is no way of ensuring that what that other department does is consistent with overall federal water policies. It is therefore in DOE's interest to provide some assistance. "How much?" is the real question and this can probably only be answered by negotiation in a forum such as the Interdepartmental Committee on Water (ICW).

Role of Industry

1. The Well Drilling Industry

In 1986 there were approximately 1500 water well drilling rigs operating in Canada. The industry employed about 3000 persons and drilled about 38 000 water wells worth approximately 230 million dollars for the wells alone. The cost of the associated water systems was an estimated 53 million dollars more.[25]

Drillers are organized into individual provincial associations which are affiliated with the Canadian Water Well Association (CWWA), a national organization. Up to recently the CWWA has maintained a low public profile, but it has lately started to seek a more active role in maintaining and upgrading industry standards and to remedy some of the deficiencies it sees in groundwater development practice.

The CWWA would be well placed to develop national guidelines on the technical aspects of water well drilling and to contribute technical expertise, either directly or indirectly, to codes of practice such as the National Building Code.

Contacts with the CWWA indicate that the Association would be interested in pursuing these questions further.

2. Manufacturing, Mining and Oil, Agriculture Industries

Whether or not industry ever was the environmental villain that some people think it was, today, more and more companies are recognizing that it is just good business to be a responsible corporate environmental citizen. They see that it is well worth while to spend some significant effort on environmental issues, including the avoidance and clean-up of groundwater contamination. For example, the Canadian Chemical Producers Association adoption of "Responsible Care" as a condition of membership, signals a desire to be a part of the solution and not just the problem.

Although there have been exceptions, by and large industry and governments have been slow to capitalize on their mutual interest in a clean environment by combining forces in cooperative research and other ventures. For example, the development of clean technologies, source and loss control techniques and the promotion of innovative management methodologies are all areas where a collaborative industry/government approach could prove very worthwhile. Some of this tardiness may be due to the nature of present environmental review practices, where governments and industry frequently are constrained to act as adversaries.

Nevertheless, there have been a few instances of successful government/industry collaboration, which encourage the belief that much more could be accomplished with relatively little effort and, potentially, very significant savings. Some examples from the groundwater area are the AECL High Level Nuclear Waste Disposal project (joint AECL/DOE/EMR plus many others);* the present Hoechst/DOE/University of Saskatchewan/University of Waterloo study of the microbiological breakdown of pesticides in groundwater; and the federal/provincial/industry 5 year R and D program to develop "walk away" technology for the problem of acid mine drainage.

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* AECL is in fact a Crown Corporation, but it acts in many respects as a part of the nuclear industry.

There is ample opportunity for highly innovative approaches to preventing groundwater (and other environmental) contamination. For example small companies find it difficult to treat, recycle or safely dispose of wastes from their operations.

In many parts of the world such companies, in co-operation with governments, are forming cooperatives for dealing with these wastes wich include metal finishing wastes, contaminated soils from oil refineries, etc. There are probably many opportunities for such co-operative ventures in Canada. These kinds of initiatives should be welcomed and encouraged.

Role of the Universities

There is a critical shortage of hydrogeologists in Canada. In 1988 there were fifty to seventy vacant positions available in government and industry for hydrogeologists. The University of Waterloo (by far the biggest and best known "supplier" of graduate hydrogeologists in Canada) graduated 56 PhD-level and MSc-level hydrogeologists in the period 1986 to 1989.[27]

This shortage has been caused by:

1) The infancy of hydrogeology as a recognized scientific discipline. Many groundwater professionals active in Canada today have received no formal training in the subject.[25] There is still little emphasis on hydrogeologic courses at the undergraduate level in most university earth science/geotechnical curricula.

2) The fact that it is only recently that the importance of hydrogeology to a wide variety of environmental issues has been generally recognized.

   Only in the last ten years or so has it been widely recognized that groundwater plays a major and often all important role in issues such as waste disposal, management of mine wastes, acid rain, lake contamination etc.

The education system has not yet caught up with the demands of the real-world market place.

3) The seemingly insatiable demand of the U.S. for trained hydrogeologists for hazardous waste studies (estimated at 25,000 professionals between nov and 1995) and the consequent high U.S. salaries with which it is difficult to compete.[25] It is estimated that 40 per cent of Canadian trained PhD graduates in hydrogeology have emigrated over the past five years, nearly all to the U.S.

Although as many as twelve universities in Canada offer "significant" graduate programs in groundwater science/engineering,[25] there is really only one which has consistently maintained an ongoing major hydrogeology program; namely the University of Waterloo. This university is barely capable of graduating enough hydrogeologists for the needs of Ontario and even then with major (provincial) government support. It is completely unable to satisfy demands for hydrogeologists for the rest of Canada.

Although other educational institutions are interested in establishing groundwater programs (e.g. University of Saskatchewan, University of New Brunswick, Technical University of Nova Scotia), they have been and are hampered in doing so by the general climate of economic restraint.

The major consequence of all these factors is that Canada is facing a serious deficiency in groundwater expertise in all segments of society - government, private sector, university - which seems likely to continue for at least the next decade.

Another consequence is that there is only a limited capability in the university sector to carry out research sponsored by outside organizations e.g. governments. It is not far off the mark to state that any university faculty member with expertise in hydrogeology can find however much contracted work as he/she wants with very little effort. Consequently, the opportunity for governments to contract out any significant part of their groundwater research requirements to qualified university faculty is strictly limited.

As far as DOE is concerned, its capability to influence the academic groundwater community and to take advantage of its considerable talents is minimal.

Since termination of the Water Resources Research Support Program (WRRSP) some years ago and the demise of the Unsolicited Proposal (UP) program of DSS in 1989, the only significant federal source of research funds for hydrogeological research is the NSERC grants program. This program is not administered by DOE and so the department's priorities and requirements are not given any special consideration. In addition, any request for funding for groundwater programs faces stiff competition from all other natural science proposals.

Those groundwater proposals which are funded do not necessarily reflect DOE's priorities but rather those of the science community.*

DOE research Institutes enter into contracts with universities to fund specific parts of the Department's own groundwater research programs. However, such contract funds are "one-shot" in nature and tend to be for highly specialized sole-source services so that they do not (and cannot) provide the kind of long term contact and influence which the department needs to maintain with the university community.

This might not be the case if the global demand for hydrogeological expertise were not so heavy, but in the present situation universities can hardly be faulted for giving their attention to and focusing their priorities on those clients who are most willing to pay.

A number of avenues exist whereby DOE's relationships with the university groundwater community could be improved:

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* In June 1990, DOE and NSERC announced a joint, one million dollar Great Lakes University Research Fund, to support Great Lakes university research. This fund will be available to support eligible groundwater projects.

1. Re-instatement of the WRRSP or the establishment of some similar program with emphasis on groundwater. There is no doubt that this would be welcomed by the universities but unless such a program were specifically targeted to groundwater it would be both expensive and inefficient in terms of re-establishing and maintaining DOE/University contacts in groundwater. When the WRRSP was cancelled, it had a budget of $250,000 annually, which was allocated between all universities in Canada doing all kinds of water resources research. Only a fraction of this amount, perhaps 15 per cent on average, was allocated to groundwater. This level of support was generally recognized as being inadequate in 1978. When compared with the size of contracts universities are accustomed to deal with ($50,000 - $100,000 is not exceptional) it is apparent that the funding allocated to a revitalized WRRSP would have to be increased substantially by at least five times, to $1.25 million, if it was going to have any significant impact on the university groundwater research community.

2. Establishment of Faculty Positions in Hydrogeology at Canadian Universities. The best known mechanism for supporting the establishment of new faculty positions in high priority fields of research is NSERC's Industrial Research Chair program.[28] Each Chair generally comprises the senior level position, together with up to six to eight supporting positions (junior faculty, research assistants, technical support) and some operating funds and cost about $7-800,000 per year per Chair, the cost of which is picked up jointly by NSERC and industry for the first five years. Wastewater Technology Centre (WTC) has had great success in attracting sponsors for Chairs in other fields.

   The cost to the Department and to the federal government as a whole could therefore be considerably less than $700,000, depending on how much external sponsorship could be attracted.

   Nevertheless, the total cost of each Chair established on the NSERC Industrial Chair model means that the number of institutions which can be supported in this way is strictly limited. The establishment of more than

two such Chairs in groundwater would appear to be extremely unlikely, and one is a much more realistic aim. However, from DOE's perspective, what is required is not so much a single additional high profile, high-powered centre for groundwater research, but rather four or five regional centres of more modest scope and size. Rather than seeking to put in place a single individual with a fully established international reputation supported by a full complement of ancillary staff (which may not even be feasible, given the global shortage of qualified hydrogeologists), it would be more to Canada's overall advantage and probably more feasible to aim at establishing younger groundwater faculty members at several universities across the country.

A reasonable target might be the establishment of a viable groundwater program at one university within each of DOE's five Regions. For this approach to succeed, it will be necessary to approach NSERC to ascertain whether it would be prepared to modify its Industrial Chair program to accommodate this approach, or, alternatively, to establish a new program to accomplish this purpose.

At present, definite interest in pursuing one or both of these strategies has been expressed by the Universities of Waterloo and Saskatchewan. Also, because of the importance of groundwater to Atlantic Canada, DOE/Atlantic Region is very interested in establishing a groundwater program at a university within that Region.

3. Secondment of Departmental Staff to University Faculty positions. Such arrangements would go beyond the present practice of appointing research staff to Adjunct Professor positions and would, in effect, amount to the department paying the salary and some operating expenses of an employee who would act in all other ways as a full-time faculty member with teaching, research and other responsibilities exactly the same as a regular faculty member.

Such appointments would mean that the department, through its employee, could have a day-to-day influence on the teaching and research activities of the University, while the University would gain the services of another

full time faculty member at no salary or operating cost other than office overhead. The cost to the department would be, of course, the person-year and salary and operating dollars that went with it.

This kind of arrangement would work best where there already existed a strong university faculty and DOE could not afford to assign more than one or two person years and a few thousand operating dollars to the topic.

In addition to these specific department/university arrangements, there are, of course many other kinds of contacts which are in wide use already or which could be developed e.g., adjunct professor appointments; cooperative departmental/university projects; training of university students at DOE research establishments; networks of centres of excellence, etc.

Role of the Groundwater Specialist

Although it would be expected that the increase in the number of groundwater related issues facing the department would call for more hydrogeologic specialists overall, it does not necessarily follow that any given groundwater problem will require large numbers of expert hydrogeologists to work on it. Each problem, or at least each type of problem has its own particular requirements which must be analysed on a case-by-case basis.

For example, there are two aspects to the Leaking Underground Storage Tank (LUST) problem; 1) prevention of leakage, by replacing and redesigning tanks and 2) cleaning up sites which have already become contaminated by leakages from older types of underground storage tank. The kinds of expertise required to replace and redesign tanks include specialists in materials technology and engineering design; very little hydrogeologic expertise is needed. However, to clean up contaminated sites requires a high level of hydrogeologic expertise. Thus, different aspects of the same groundwater issue may differ enormously in their requirements for groundwater expertise.

Nevertheless, some generalizations can be made:

1. Cleaning up contaminated sites is technically very complex and expensive and will generally require access to state-of-the-art hydrogeologic expertise.

2. Development of certain types of guidelines e.g., for deep well disposal of wastes, will also call for detailed and highly specialized hydrogeologic knowledge. On the other hand, development of some other kinds of guidelines, e.g., for groundwater data exchange, will require less highly specialized groundwater expertise together with a reasonably high level of expertise in data handling.

3. Certain operational activities such as emergency spill-site investigations or CEPA inspections will require a capability to recognize actual or potential groundwater contamination situations on the spot. This requires field officers to have a general knowledge of hydrogeology, but does not require them to be highly specialized groundwater experts. However, such experts must be available to the department in case the field officer recognizes a potentially serious situation requiring immediate action.

These considerations lead to the conclusion that although a significant augmentation in DOE's hydrogeologic expertise is required, expertise in other disciplines will also be needed.

Some of the increased expertise will have to be acquired by hiring highly specialized Ph.D-level experts in fields such as groundwater contamination. Other, less highly specialized expertise may become available as the education system begins to respond to the present critical shortage of hydrogeologists, (for example, University of Waterloo will be starting to offer a Bachelor's-level program in hydrogeology in the fall of 1990.[37] However, graduates will not become available from this program until 1994 at the earliest). Technical colleges can provide some of the technical expertise required. Nevertheless, because of the overall shortage of groundwater expertise and the time required for training graduate hydrogeologists, extensive use will need to be made of retraining of existing staff, at least for the next four to five years. The department will have to develop a carefully thought-out training program to satisfy many of its various needs for groundwater expertise.

Role of Environmental Non-Governmental Organizations (ENGOs) and other Advocacy Groups

As noted elsewhere in this report, there has never been an active lobby for groundwater issues in Canada comparable to those for other environmental issues. ENGOs have not been consistently active in pushing for action on groundwater issues across the country, although some groups have been active locally.

The reason for this apparent relative lack of interest in groundwater by the public and by advocacy groups is not clear; it may be that this is another manifestation of the"out-of-sight, out-of-mind" syndrome, or perhaps a lack of information on the importance of groundwater to many of today's environmental issues.

The main role played by those organizations which have interested themselves in groundwater has been in the area of public information. For example, the Conservation Council of Nev Brunsvick worked with DOE to produce a Groundwater Pollution Primer.[38] The Girl Guides of Canada have produced an information guide on groundwater for use in their ongoing activities.[39]

These productions have been well done and serve a very useful purpose in informing the groups' clientele about groundwater. The continuing involvement of these kinds of organizations in public information activities concerning groundwater is to be welcomed and encouraged.

The current concern with environmental assessment and the recently tabled federal legislation offer the opportunity to ENGOs to become involved in environmental assessments of development projects, which often include groundwater-related issues. To the extent that ENGOs take up groundwater concerns in these projects, this is all to the good.

Other non-governmental organizations have played an important role in helping governments develop policies, strategies, e.g., a recent federal government

workshop on sustainable development, where coordination and rapporteur functions were provided by an NGO[35] and where many of the speakers were affiliated with NGOs of one kind or another. This kind of service could well be very useful in the development of specific groundwater strategies, e.g., guidelines.

CURRENT ACTIVITIES AND RESOURCES WITHIN DOE

Table 1 is a compilation of resources allocated to groundwater activities in DOE for fiscal years 1989/90 and projected for 1990/91.

Table 1 shows how many pys and dollars are allocated to each of the policy elements identified in the section of the Federal Water Policy relating to groundwater contamination. As DOE is not spending any significant resources on groundwater issues other than contamination, the figures given in Table 1 can be regarded as applying to groundwater issues in general.

Table 1 distinguishes between the total py resources devoted to groundwater issues and the number of pys allocated to experts in hydrogeology. Failure to make this distinction has caused considerable misunderstanding and confusion in past exercises of a similar nature.

Overall Levels of Resources

It is difficult to make purely objective judgements as to whether the overall numbers of resources (pys and dollars) being allocated to groundwater activities by DOE are appropriate. Over the past ten years or so, groundwater managers have become aware that they are getting increasingly short of both py and dollar resources to address the concerns they are being asked to deal with. Various estimates of the shortfall have been made over the years. These have all agreed that the Department needs between twenty and forty additional pys and an additional $2-3 million in order to do an adequate job on the groundwater issues it is facing. This corresponds roughly with doubling the size of DOE's groundwater program. It should be noted that these estimates were made at times before the implications of CEPA and the recently announced environmental assessment legislation were understood.

TABLE 1

RESOURCES DEVOTED TO GROUND WATER ACTIVITIES
DOE

REGION/RESPONSIBILITY CENTRE: DOE TOTALS

POLICY ELEMENT	1989 - 1990						1990 - 1991					
	PY			$			PY			$		
	*H.E.	OTHER	TOTAL	A-BASE	OTHER	TOTAL	*H.E.	OTHER	TOTAL	A-BASE	OTHER	TOTAL
Strategy/ Guideline Development	2.2	0.6	2.8	23.0	181.5	204.5	2.4	0.7	3.1	28.5	191.5	220.0
Research, Development & Demonstration	13.1	3.4	16.5	737.3	920.4	1657.7	13.4	3.6	17.0	695.5	1145.0	1840.5
Manage Federal Responsibil-ities	2.4	3.2	5.6	62.0	94.1	156.1	2.8	5.5	8.3	85.0	155.0	240.0
Transboundary Water Quality	1.2	1.2	2.4	34.0	32.0	66.0	2.4	2.9	5.3	44.0	432.0	476.0
Advice on Fed/National Issues	2.7	1.9	4.6	188.0	230.0	418.0	3.0	2.3	5.3	219.0	230.0	449.0
Other (please specify)	0.2	—	0.2	1.0	—	1.0	0.2	—	0.2	1.0	—	1.0
T O T A L S	21.8	10.3	32.1	1045.3	1458.0	2503.3	24.2	15.0	39.2	1073.0	2153.5	3226.5

* Hydrogeological Expertise

Internal Balance of DOE's Groundwater Activities

However adequate or inadequate the overall allocation of resources to DOE's groundwater programs may be, it is nevertheless essential to examine the distribution of those resources which are allocated to groundwater between the five policy elements. This helps to identify those policy elements which are most in need of increased attention.

Table 2 shows the resources devoted to the various groundwater policy elements by C and P as percentages of the total resources devoted to groundwater activities. (As essentially all DOE's groundwater activities take place in C and P, the following discussion can be regarded as aplying to the Department as a whole).

The most striking feature of the table is the proportion of resources allocated to Research, Development and Demonstration (51 per cent of the pys and 66 per cent of the dollars. When salaries are included in the dollar totals, the dollar percentage becomes 61 per cent, Table 3). The question arises as to whether this heavy emphasis on R, D and D or, to put it another way, the relative weakness in operational activities is appropriate for DOE groundwater activities. Table 4 shows the proportion of resources C and P as a whole allocates to its six research institutes, relative to its total resource allocations. These overall C and P allocations for R, D and D activities, expressed as percentages are 22 per cent of its pys and 25 per cent of its dollars (including salaries).

What this means is that regardless of the absolute amount of resources C and P allocates to groundwater, it spends about 2½ times more on R, D, and D relative to its non-research groundwater activities than it does in its other areas of activity.

The actual figures given here should be considered with caution; there is nothing graven in stone saying that the ratios for groundwater <u>should</u> be the same as for C and P overall. In addition, C and P percentages are probably somewhat low, because even though C and P overhead has been removed, they still include overheads which the groundwater numbers do not.

TABLE 2

Resources Devoted to Groundwater Activities

Conservation and Protection

POLICY ELEMENT	1989 - 1990				1990 - 1991			
	PY	% PY	$	% $	PY	% PY	$	% $
Strategy/Guideline Development	2.8	8.7	204.5	8.2	3.1	7.9	220.0	6.8
Research, Dev. & Demonstration	16.5	51.4	1657.7	66.2	17.0	43.4	1840.5	57.0
Manage Federal Responsibilities	5.6	17.4	156.1	6.2	8.3	21.2	240.0	7.4
Transboundary Water Quality	2.4	7.5	66.0	2.6	5.3	13.5	476.0	14.8
Advice on Federal/ National Issues	4.6	14.3	418.0	16.7	5.3	13.5	449.0	13.9
Other	0.2	0.7	1.0	0.1	0.2	0.5	1.0	0.1
T O T A L S	32.1	100.0	2503.3	100.0	39.2	100.0	3226.5	100.0

TABLE 3

GROUNDWATER ACTIVITIES C AND P 1989/90
(rounded figures)

	PY	$ (K)	(pt X 43K) Sal	Total $K
R, D & D	16.5	1657.7	709.5	2367.2
Other	15.6	845.6	670.8	1516.4
Total	32.1	2503.3	1380.3	3883.6
Groundwater % R, D & D Total	51.4	(66.2)	--	61.0

TABLE 4

C AND P ACTIVITIES, 1989/90 BUDGET ALLOCATION

	PY	$M
C and P Total	2382.	252.
Less C and P Management	- 135.	- 12.6
C and P (exclusive of Mgmt)	2247	239.4
C and P Research Institutes	489.5	60.2
C and P Research Institutes % of C and P Total (exclusive of Mgmt)	22.	25.

Nevertheless, there is no doubt that these numbers confirm that C and P is gravely deficient in its allocation of resources to operational (i.e., non-R, D and D) groundwater programs in comparison with its allocation to research programs.

The effect of this situation, when taken within the context of the overall shortage of groundwater expertise within DOE, has been that the R, D and D components of C and P's groundwater program (primarily the two IWD Institutes) have been placed under greater and greater pressures to become involved in operational work, with detrimental effects on their groundwater research activities.

Considering the three policy elements "Federal Responsibilities", "Transboundary Water Quality" and "Advice", these three elements are primarily the responsibility of the Regions. The allocations of resources to these elements presumably reflect the judgement of Regional management as to the priority of groundwater vis-à-vis other Regional priorities. As Regions know best what their own priorities are, there is not much more that can be said about these three policy elements other than to repeat what was said before about Regional groundwater managers believing that their groundwater activities are seriously under-resourced. This judgement is likely to be reinforced as the requirements for groundwater expertise needed to implement CEPA and the new environmental assessment legislation become apparent.

With regard to Strategy/Guideline Development, it is not clear that the few pys and dollars dedicated to this policy element reflect any kind of management decision that this is indeed an appropriate level of resources. Major responsibility for this policy element would seem to lie with DOE/HQ, with Regions playing some role in implementing the strategies and guidelines developed by HQ in their Regions. No organization in DOE is charged specifically with the responsibility for developing strategies and guidelines for groundwater and (apparently) no organization is doing so in any systematic way.

Although some research projects are directed towards the eventual aim of developing guidelines and strategies for specific practices (e.g. subsurface injection of liquid wastes), no mechanisms appear to exist whereby DOE could draw on the results of such research studies to develop guidelines and strategies. This certainly seems to be an area where action is urgently required.

CONCLUSIONS AND RECOMMENDATIONS

The Groundwater Results Definition Model (GRDM)

The foregoing analysis and discussion demonstrates that the groundwater issue is complex and involves many different kinds of problems. Therefore, DOE's approach to the groundwater issue and the remedies it brings to the problems identified will also be complex; action is required on a wide variety of fronts.

Various formats could be used to present the conclusions and recommended actions. Here, a scheme based on the Results Definition technique has been chosen, because:

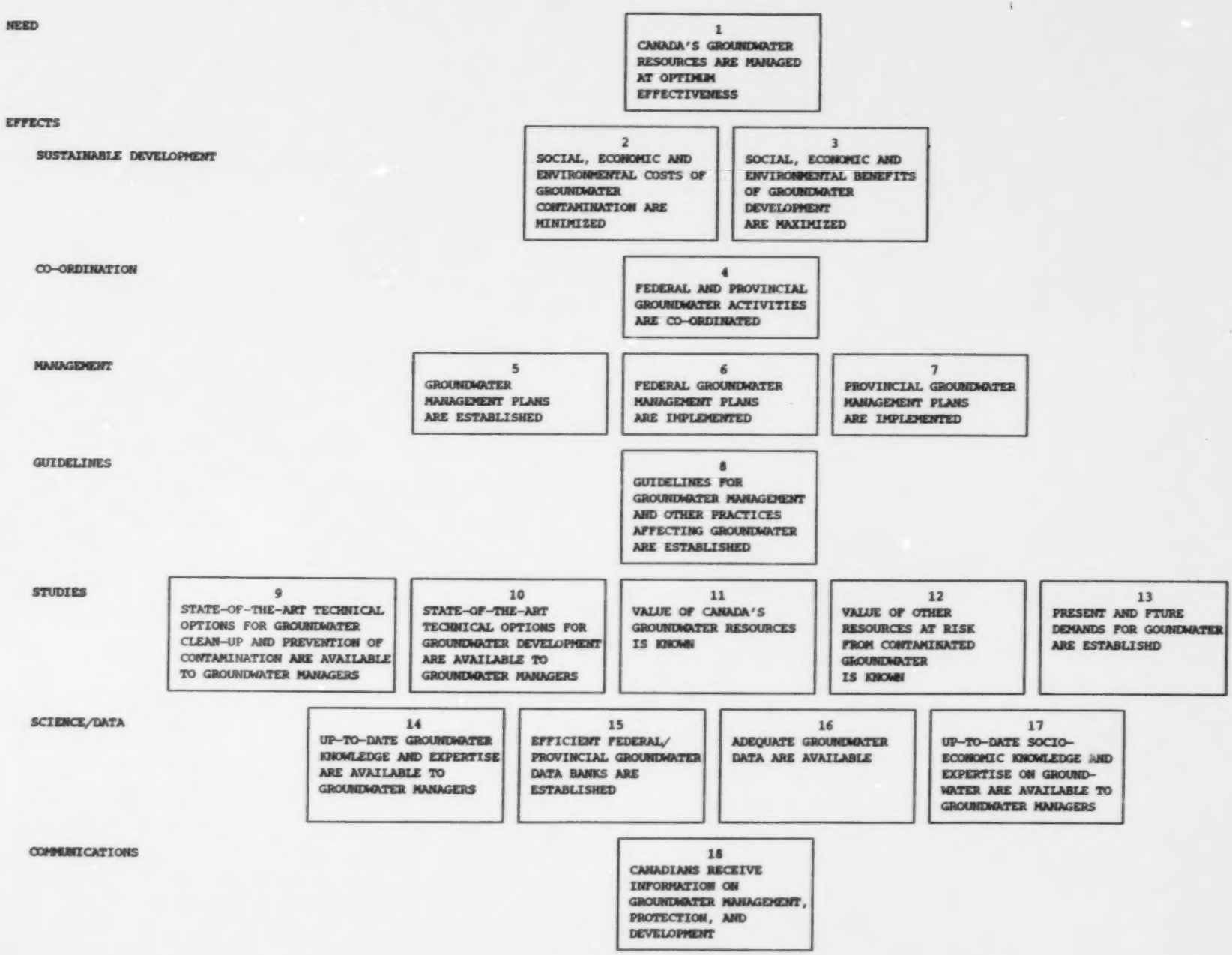
- the Results Definition Model has been widely used within DOE Conservation and Protection (C and P) as a planning tool and therefore managers are familiar with it; and

- the present C and P Program Activity Structure (PAS) is based on the Results Definition approach, so that the conclusions and recommendations of this report can be related to an existing concept and definition of how C and P goes about its business.

Because this Report deals with only a small part of C and P's programs, the model presented here is at a much finer scale than the C and P Program Activity Structure and exact correspondences between the Groundwater Results Definition Model (GRDM) and the PAS cannot be made. Nevertheless, there is a general correspondence between the GRDM and the PAS which should help in placing the conclusions and recommendations in context.

The Groundwater Results Definition Model is shown in Figure 1. In describing the various Model Elements, two scenarios are described; the Baseline Program where only insignificant internal resource transfers would be made and the Enriched Program, which would be implemented only if significant new resources were made available. A summary of the resource requirements for the Enriched Program is given in Table 5, at the end of this section.

FIGURE 1 - THE GROUNDWATER RESULTS DEFINITION MODEL


NEED
1
CANADA'S GROUNDWATER RESOURCES ARE MANAGED AT OPTIMUM EFFECTIVENESS
EFFECTS
SUSTAINABLE DEVELOPMENT
2
SOCIAL, ECONOMIC AND ENVIRONMENTAL COSTS OF GROUNDWATER CONTAMINATION ARE MINIMIZED
3
SOCIAL, ECONOMIC AND ENVIRONMENTAL BENEFITS OF GROUNDWATER DEVELOPMENT ARE MAXIMIZED
CO-ORDINATION
4
FEDERAL AND PROVINCIAL GROUNDWATER ACTIVITIES ARE CO-ORDINATED
MANAGEMENT
5
GROUNDWATER MANAGEMENT PLANS ARE ESTABLISHED
6
FEDERAL GROUNDWATER MANAGEMENT PLANS ARE IMPLEMENTED
7
PROVINCIAL GROUNDWATER MANAGEMENT PLANS ARE IMPLEMENTED
GUIDELINES
8
GUIDELINES FOR GROUNDWATER MANAGEMENT AND OTHER PRACTICES AFFECTING GROUNDWATER ARE ESTABLISHED
STUDIES
9
STATE-OF-THE-ART TECHNICAL OPTIONS FOR GROUNDWATER CLEAN-UP AND PREVENTION OF CONTAMINATION ARE AVAILABLE TO GROUNDWATER MANAGERS
10
STATE-OF-THE-ART TECHNICAL OPTIONS FOR GROUNDWATER DEVELOPMENT ARE AVAILABLE TO GROUNDWATER MANAGERS
11
VALUE OF CANADA'S GROUNDWATER RESOURCES IS KNOWN
12
VALUE OF OTHER RESOURCES AT RISK FROM CONTAMINATED GROUNDWATER IS KNOWN
13
PRESENT AND FTURE DEMANDS FOR GOUNDWATER ARE ESTABLISHD
SCIENCE/DATA
14
UP-TO-DATE GROUNDWATER KNOWLEDGE AND EXPERTISE ARE AVAILABLE TO GROUNDWATER MANAGERS
15
EFFICIENT FEDERAL/ PROVINCIAL GROUNDWATER DATA BANKS ARE ESTABLISHED
16
ADEQUATE GROUNDWATER DATA ARE AVAILABLE
17
UP-TO-DATE SOCIO-ECONOMIC KNOWLEDGE AND EXPERTISE ON GROUND-WATER ARE AVAILABLE TO GROUNDWATER MANAGERS
COMMUNICATIONS
18
CANADIANS RECEIVE INFORMATION ON GROUNDWATER MANAGEMENT, PROTECTION, AND DEVELOPMENT

NEEDS

Model Element 1. Canada's Groundwater Resources are Managed at Optimum Effectiveness

The preceding sections of this report have established that there is a long way to go before this need is met. In fact, there are serious deficiencies in the management of groundwater at all levels of government across Canada.

The groundwater issue has escalated in importance so rapidly that governments have been ill-prepared to meet it. Lacking the basic management tools to deal with groundwater issues and lacking the time and expertise to develop them, governments have been forced onto the defensive to the point where everything else is being sacrificed to crisis management. Fundamental management requirements such as groundwater data banks are being stripped of resources in order to deal with a seemingly endless series of fire-fighting episodes. Rather than develop longer term integrated management strategies, governments have adopted, almost exclusively, a regulatory approach which seemed to offer a quick response to the problems faced. However, it is now becoming increasingly clear that the regulatory approach, however essential it may be as a component of an overall groundwater strategy, cannot by itself deal with the fundamental problems of groundwater management. Nor do the firefighting clean-up efforts appear to be achieving what was hoped and expected of them.

Facing a probable clean-up bill of several billion dollars now, and with the prospect that that figure will grow by leaps and bounds as new groundwater contamination occurrences come to light, the country simply cannot afford to continue with its present approach. Regardless of who pays the bill directly, the implications for the viability of national, regional and local economies are serious. Questions of jurisdictional authority become secondary in a crisis of these proportions. The public seems to sense this in holding the federal government accountable for doing something about the situation, regardless of the fact that groundwater management is very largely a provincial responsibility.

The problem has been that no-one knew what to do about the situation because no-one knew what the real problems were. Now that it is becoming clear that "quick-fix" approaches do not work, the fundamental importance of the basic resource management tools that are well known (but seem to have been temporarily forgotten) is reappearing as is shown in the foregoing sections of the report. A valuable summary of the fundamentals of a sound groundwater management system is the recently issued ECE Charter on Groundwater Management.[36]

Once these management tools are organized and are operating effectively, there is no reason why they cannot continue to do so indefinitely.

If these tools are put in place, what today appear to be almost insuperable difficulties will be just another job for the system tomorrow. At that time, the provinces will be much better placed to look after their responsibilities and the federal government will be able to play a much less prominent role.

Recommendation 1 - It is recommended that the goal of the federal government's groundwater strategy should be to assist the provinces in establishing effective, viable groundwater management systems and mechanisms, with the aim of having them in place in five years. After this time the federal government would decrease its involvement in and expenditures on groundwater to that level required to take care of purely federal groundwater concerns (maintenance level).

EFFECTS - SUSTAINABLE DEVELOPMENT

Model Element 2. The Social, Economic and Environmental Costs of Groundwater Contamination are Minimized

One of the problems with the existing approach to groundwater contamination is that it takes little account of the variability of social, economic and environmental values across the country or, indeed, within regions or parts of regions. The cost of contaminating an aquifer which serves as a water supply for a million people is obviously much greater than the cost of contaminating in a similar way an aquifer which serves half a dozen farms. This is true whether the costs are measured in terms of the cost of obtaining an alternative supply or in terms of increased health care costs or additional water treatment. However, the cost of cleaning up the contamination is the same in both cases; always assuming it can be done at all. When these factors are taken into account, it may well make sense in the one case (the one million people) to clean up the aquifer and in the other case (the six farms) to truck in water supplies and not try to decontaminate the aquifer. Unfortunately, this is not what usually happens, it is more often a case of "clean-up at all costs". As mentioned earlier in this Report, one of the major reasons why economic analysis has been neglected with regard to groundwater is that Canadian society grossly undervalues its water, whether surface or groundwater, so it is very difficult to establish a realistic cost for any given incident of groundwater contamination.

For the same reason it is also difficult to assess what it is worth to protect groundwater from contamination, before it occurs.

Model Element 3. The Social, Economic and Environmental Benefits of Groundwater Development are Maximized

This effect is, of course, the complement to the previous Element and the two together comprise the essence of "Sustainable Development".

The country's mechanisms and procedures for guiding the development of groundwater resources are as primitive as are those for groundwater contamination, the major difference being that the contamination aspect has received much more public and media attention. For instance, it is generally assumed that the Prairies are or shortly will be facing serious water supply difficulties.

Yet essentially nothing has been done to investigate hov existing supplies might be augmented by innovative groundwater development and very little to establish a realistic price for water in the area in order to assess the economic viability of any such schemes. When Elements 2 and 3 are considered together, they point out an urgent requirement for some way of managing competition for the available groundwater resource, whether that competition is between environmental and economic interests, competing economic interests or any number of varying interests.

Recommendation 2 - It is recommended that the systems and mechanisms identified in Recommendation 1 should contain, as a fundamental characteristic, procedures and systems for resolving competition for groundwater resources from all perspectives (social, economic and environmental), and for protecting and remediating groundwater sources.

EFFECTS - COORDINATION

Model Element 4. Federal and Provincial Groundwater Activities are Co-ordinated

Of all the Effects, this one is probably the key to the success of any DOE or federal government groundwater strategy. Certainly, lack of coordination of groundwater activities within DOE has been and continues to be a major impediment to the effectiveness of DOE's groundwater programs. But this lack of co-ordination is not confined to DOE. Although mechanisms such as the Interdepartmental Committee on Water (ICW) and the Canadian Council of Ministers of the Environment (CCME, formerly CCREM) operate effectively in other resource areas, they have had little or no effect on the way groundwater programs at the federal or federal/provincial levels have been handled. This report indicates that it is essential to get bodies such as these not only to support the strategy but to actively promote it, if it is to succeed. In turn this implies that there must be some significant benefits to these bodies and their constituent members in endorsing and adopting the strategy. Some of those benefits have been discussed in previous sections. For example, by moving away from a purely "protectionist" approach and placing more emphasis on "sustainable development" kinds of approach, it offers a way of dealing with the groundwater issue without sacrificing the economic goals of other departments and provincial agencies. However, this implies that DOE and other federal departments, together with provincial agencies must come to a mutual understanding and agreement about environmental and development goals and how they are to be achieved and even more importantly, how differences of viewpoint are to be reconciled. This mutual understanding is the essence of what Sustainable Development and the Green Plan are about. Although significant progress is being made,[35] it does not yet exist at the federal level, or at the federal/provincial or provincial levels.

But, even when this meeting of minds has taken place, it will not be enough, on its own, to ensure that progress towards sustainable development and specifically towards sound groundwater management will take place. Bodies such as CCME and ICW will have major roles to play in co-ordinating federal,

provincial and departmental programs, but without some real influence or power, such groups run the risk of turning into "showcase forums" with more visibility than influence. Lack of such "clout" is a criticism which has been levelled at some coordinating bodies in the past. To the extent that this charge is true, such bodies would therefore tend to be inappropriate for co-ordinating federal groundwater programs.

Recommendation 3 - DOE should establish a Working Group on groundwater to co-ordinate all DOE's groundwater activities. The Working Group should have a full time Chairperson and this individual should be allocated a budget to be applied to the work of other DOE groups active in groundwater. The Chairperson would be the primary contact point for groundwater matters falling under the auspices of ICW or CCME.

At the working level, various co-ordinating groups have been created over the years to deal with federal/provincial co-operation in groundwater. Two of the more long-lived are the Committee on Groundvater of the Prairie Provinces Water Board (PPWB/COG) and the Atlantic Water Resources Group (AWRG). Membership of PPWB/COG includes representatives from Alberta, Saskatchewan and Manitoba, together with federal representatives from DOE and PFRA. AWRG began as an informal group of government personnel working in groundwater in the Atlantic Provinces and included representatives from New Brunswick, Nova Scotia, Newfoundland, Prince Edward Island and the federal government. Later, the interests of AWRG expanded to encompass all water resources issues, but groundwater remains a key interest of the group.

In addition to these two bodies, which are well established, there have been numerous informal federal-provincial groups established on an ad-hoc basis to deal with various national groundwater issues that arise from time to time. The recent federal-provincial Workshop on Groundwater Data Banks is an example of this type of federal-provincial groundwater group.

Such groups have been useful, in that they have certainly served to exchange information and ideas. However, they have not really been much more than informally organized meetings, to discuss issues of the day. None has achieved any degree of permanence and none has had any substantial effect in coordinating federal and provincial groundwater programs.

One reason for this is that the federal and provincial programs have had little in common. Federal interests have been primarily in the field of research, while provinces have been mainly concerned with the "nuts and bolts" of groundwater management such as licensing well drillers, controlling flowing wells etc. To be sure, there has been a significant degree of co-operation between DOE and many provinces on particular groundwater issues but these cooperative efforts have usually come about independent of any formal or informal coordinating mechanisms.

Another reason for the lack of effectiveness of many past federal-provincial coordinating groups has been that there has been little economic incentive for the different levels of government to cooperate. DOE has rarely had significant resources for groundwater to put on the table as an incentive to the provinces to enter into cost-shared agreements and provinces have not had the resources to help to sponsor particular pieces of research.

This Strategy is proposing a much more active federal role in non-research groundwater activities than has ever been the case before; even under the Baseline program. There is, therefore, reason to believe that future federal-provincial coordinating bodies will have more success than hitherto. One of the primary functions of the chairperson of the DOE Working Group on Groundwater should be to establish and maintain coordinating mechanisms with all provinces, building on current initiatives, such as the recent Workshop on Groundwater Data Banks.

Recommendation 4 - It is recommended that the Chairperson of the DOE Working Group should establish and maintain co-ordinating mechanisms with the provinces, such as federal-provincial working groups. Such groups should be permanent and meet regularly.

Resource Implications for DOE

Baseline Program

The establishment of the Working Group and its ongoing operations can be achieved by minor reallocation of existing resources including the appointment of the chairperson. It is considered essential that this position be established on a full time basis and that the position be classified at a high enough level so that individuals with experience in all areas of groundwater (policy, scientific, program management) can be attracted.

In addition to the duties of Chairperson of the DOE Working Group on Groundwater, the proposed new position could also assume responsibility for other proposed initiatives, such as establishing and maintaining co-ordination with the provinces, administering a Groundwater Research Support Program (see Recommendation 20, below). Resource implications for these initiatives will be dealt with under other recommendations.

Enriched Program

If DOE groundwater activities increased substantially as a result of new initiatives, the workload of the Chairperson would become too much for one person and additional support would be needed. This is estimated to be 2 py and associated operating dollars.

Additional Resources Required for Enriched Program

Purpose	Py	$
Coordination of DOE federal and provincial groundwater activities.	2	$100-150,000

Model Element 5. Groundvater Management Plans are Established

In order to manage groundwater (or any other resource) rationally, a plan must be in place establishing procedures, mechanisms for resolving competition and allocation, priorities, etc.

There are two distinct but closely linked aspects to this effect:

- the establishment of groundwater management plans for federal facilities, lands and responsibilities; and

- the establishment by the provinces, with federal assistance, of their own groundwater management plans.

The body of the report indicates that one of the major causes of the problems the country now faces in the groundwater area is that there has been too much emphasis on "quick-fix" solutions and crisis-response at the expense of the development of groundwater management.

When established, groundwater management plans could include, but are not restricted to:

1. Enactment of legislation and promulgation of regulations to control land use in order to help prevent groundwater contamination.

2. Establishment and operation of realistic groundwater withdrawal licensing systems, taking into account the value of the water extracted and its intended use, the need to preserve the groundwater resource for the use of future generations, the economic costs and benefits to society of allowing or disallowing the request to withdraw groundwater and other relevant environmental and socio-economic factors.

3. Establishment of guidelines for various groundwater related practices and promulgation of regulations based on those guidelines.

4. Establishment and operation of efficient groundwater data banks.

5. Establishment of pollution prevention measures including emergency response procedures to prevent or minimize groundwater contamination from normal operations, spills, accidents, fires, etc.

6. Establishment of procedures and guidelines for carrying out the groundwater aspects of environmental assessments.

7. Establishing protocols, procedures, guidelines for implementing the provisions of the Canadian Environmental Protection Act and other Acts, as they apply to groundwater.

Most of the work to be done to implement this Effect is the responsibility of and would be done by the provinces. The federal government would be involved in developing plans for federal facilities, lands and responsibilities including environmental assessments, and would also contribute to the provincial activities through some CWA-type cost sharing agreement.

Although federal and provincial groundwater management plans would differ considerably due to the two government's differing responsibilities, there would be nevertheless large areas of overlap, for example in the area of environmental assessments of the groundwater aspects of mining and energy developments, dams and other major construction projects, hydroelectric developments, etc. It would be in the interests of all governments to manage this kind of process in compatible, if not similar ways and there would therefore be significant benefits if governments acted in concert to develop such management plans. Support to the provinces for the specific components of this Element (see below) should be made contingent on the province developing and putting in place groundwater management plan(s) taking into account considerations 1 to 7 above.

Recommendation 5 - It is recommended that DOE through the Canada Water Act or some similar mechanism, offer to share with the provinces the costs of developing guidelines, data banks, and other groundwater management tools, provided that Provinces agree to develop and put in place effective groundwater management plans.

Recommendation 6 - It is recommended that DOE in co-operation with other federal agencies develop groundwater management plans for areas of federal jurisdiction and responsibility.

Resource Implications

Baseline Program

Initially, the establishment of national groundwater management plans requires discussion and agreement between the various parties involved at the various levels, e.g., within DOE, within the federal government and between the federal and provincial governments. The aim of these discussions should be to establish, within a time frame of say, one year, agreements on:

1) What elements should comprise the groundwater management plans? (e.g., what guidelines and regulations are required; what administrative mechanisms are needed; how can the provisions of CEPA, Part IV be best met, etc.).

2) A timetable for implementing the plans within the next four years, together with estimates of resources required to do so. Much of stages 1) and 2) could be carried out using existing py and $ allocations. Some special studies might be required (although most of these would fall under other elements), but, provided these were not too many and they were not major undertakings, they could probably be funded out of existing allocations or, at worst, with relatively minor adjustments to existing programs.

Enriched Program

Until Stage 1) has been completed it is difficult to estimate what additional resources would be required to put the plans in place. Some resources over and above existing allocations might be required to fund contracted studies.

Model Element 6. Federal Groundvater Management Plans are Implemented

This, together with Element 7, is the Element where all the planning, data collection, research, economic analysis and so on carried out in other Elements of the model finally make contact with the real world.

It involves the day-to-day application of the principles, policies, guidelines, etc. established previously through decisions taken on, for example, whether to issue a permit for a development to proceed; hov much groundwater an applicant will be permitted to pump; which contaminated sites should be remediated; the prosecution of an offender under Section 37 of the Fisheries Act; the acceptance or rejection of a nev pesticide for a specific use; the containment and clean-up of a toxic chemical spill; inspection of contaminated sites under CEPA; and so on.

In principle any federal government department has a role to play in this Element, because the impacts of government decision-making are so pervasive. In practice, the main federal departments concerned with this Element would be Environment, Agriculture, Health and Welfare, Energy, Mines and Resources, Indian and Northern Affairs, Transport Canada and National Defence.

Because so many departments have a role in federal groundvater management, it is unrealistic to hope to establish one agency to look after all federal decision-making on groundwater. Therefore each department will run its own groundwater programs on a day-to-day basis while keeping other departments informed through periodic meetings of the Interdepartmental Committee on Water (ICW) or its equivalent.

Because of Regional differences in geography, demography and so on, different Regions will discharge this responsibility in different ways within the overall framework of national guidelines and priorities.

Recommendation 7. It is recommended that DOE and other federal departments review their allocations of resources to groundvater activities and make appropriate re-allocations or provide for training where this appears to be necessary.

Recommendation 8. It is recommended that major new resources should be allocated to operational groundwater activities.

Resource Implications

Baseline Program

As mentioned previously, at present DOE Regions are seriously deficient in their capability to deliver federal operational groundwater programs. The same presumably also applies to other federal departments. Recommendation 7 proposes that DOE Regions and other departments review and reallocate resources to groundwater activities where groundwater issues are perceived as having a high enough priority. Training and retraining of existing staff will also be required to meet the demands of new responsibilities, such as CEPA Part IV inspections, emergency spill inspections etc. To some extent this is already happening. However, reallocation and retraining will not come close to meeting the full requirements for groundwater py and $ resources in order to meet federal groundwater responsibilities.

Enriched Program

Although some of the current resource deficit could no doubt be made up by reallocation and retraining, nevertheless a significant shortfall will remain. If new resources became available for groundwater programs, it is proposed that a major proportion of such resources be allocated to augment DOE and other departments' operational groundwater capabilities. The priority assigned to these new operational groundwater resources should be second only to the resources required for the development of national guidelines and strategies.

Additional Resources Required for Enriched Program

Purpose	Py	$
Regional groundwater activities	25	$1.25 million

Model Element 7. Provincial Groundvater Management Plans are Implemented

This is the provincial counterpart to Element 6, which deals with the implementation of federal groundwater management plans. As provinces have by far the major responsibility for groundwater, overall this Element probably represents the great majority of groundwater activities carried out in Canada.

By definition, the federal government has no role to play in this Element.

EFFECTS - GUIDELINES

Model Element 8. Guidelines for Groundwater Management and other Practices Affecting Groundwater are Established.

Some of the different kinds of Guidelines and Strategies which have been proposed for development are listed on pages 22 to 23. No doubt there are many others. Both federal and provincial governments have a direct interest in these guidelines (because they apply to all activities, regardless of jurisdictional considerations) so that a joint federal/provincial approach is the only realistic alternative. Questions of priority, timetables, amount of detail to be included, funding required and all other relevant questions should be settled by federal/provincial consultations.

A variety of organizations and individuals could contribute to the development of the various Guidelines.

For example, national organizations such as the Canadian Water Well Association (CWWA) might well be best placed to actually prepare guidelines for matters such as standards for well construction and abandonment, training levels for drillers, etc.

On the other hand, within DOE, IWD's Water Quality Branch (WQB) has the responsibility for advising on which "orphan" sites should be dealt with first and it seems appropriate that that Branch should be responsible for developing guidelines relating to that program.

The University of Waterloo has extensive experience in investigating groundwater contamination, so it is eminently qualified to develop a Waste Site Monitoring Manual.

There are no general rules to establish what organization will develop guidelines; the specific circumstances of each situation and common sense are the main criteria.

However, as noted in the earlier sections of this report, the Development of Guidelines and Strategies is the one element of the Federal Groundvater Policy which is definitely not receiving an adequate share of resources. This indicates that not enough is being done to translate existing scientific knowledge in the literature and nev knowledge being developed by research Institutes and others into a form where this knowledge can be applied to guide our approach to practical real-world problems, i.e., into Guidelines and Strategies.

Other federal departments would have a role to play in developing certain guidelines. For example, Agriculture Canada would have to be involved in the development of any guidelines relating to pesticides and groundvater. Energy, Mines and Resources and CMHC would have a role in developing guidelines relating to ground-based heat-pumps. Health and Welfare would be concerned with any guidelines relating to groundvater used as drinking water.

Recommendation 9. It is recommended that DOE approach other federal departments and the provinces with a proposal to jointly develop National Guidelines and Strategies relating to groundvater and activities which impact on groundwater. Funding of the development of specific Guidelines would generally be cost-shared according to some appropriate formula, but in cases of particular federal importance DOE would provide 100 per cent funding.

Recommendation 10. It is recommended that DOE allocate a person-year immediately to hire a hydrogeologist to develop National Groundvater Guidelines and Strategies.

Resource Implications

Baseline Program

Significant progress can be (and is being) made towards developing national guidelines and strategies using existing resource allocations and nev allocations from other programs.

For example, DOE is addressing the question of guidelines for data banks using reallocation and proposed LTOP increases. The development of guidelines for clean-up and for priority-ranking of contaminated sites is being funded out of the National Contaminated Sites program. Undoubtedly there exist other opportunities to redirect existing resources towards guideline development. However, these reallocations will not be enough to address all of the issues involving guideline development, particularly those involving interdepartmental and federal-provincial cooperation.

Enriched Program

Guideline and strategy development is such a key part of the establishment of viable groundwater management plans that it should be given first priority in any allocation of new resources, whether these come from new initiatives or are obtained by reallocation. It is visualized that most of the actual work of developing guidelines (especially the interdepartmental and federal/provincial activities) would be contracted. Assuming that 2 to 3 separate topics would be dealt with each year (resulting in 10-15 sets of guidelines over five years), the annual $ resources which would be required would be between $100 - 150 000.

Additional Resources required for Enriched Program

Purpose	Py	$
Supervise development of national guidelines and strategies.	1	--
Contracted guideline development	--	$100 - 150 000

EFFECTS - STUDIES

Model Element 9. State-of-the-Art Technical Options for Groundwater Clean-Up and Prevention of Contamination are available to Groundwater Managers.

This is one area of groundwater management where the desired results (or Effects) are closest to actually being achieved, primarily through the efforts of various DOE components such as Wastewater Technology Centre (WTC) and the River Road Environmental Technology Centre (RRETC). Generally, DOE managers are well informed about the technical options available for cleaning up contaminated groundwater. (Whether or not this technical knowledge is well applied to real-world problems is another matter and DOE's record in actual groundwater clean-up has been seriously questioned).

Conventional and innovative approaches for involving the private sector and the university community have been adopted (e.g., use of the NSERC Industrial Chair program, establishment of the National Groundwater and Soil Remediation Program (GASReP)). If there is a problem with the achievement of this Effect it lies in the co-ordination of the efforts of the people working in this area with those in other Elements of the model. To use a hypothetical example, if it turned out that deep subsurface disposal of liquid wastes was unacceptable for hydrogeologic or other reasons, there would be no point in spending much time and effort in developing efficient technologies to carry out deep subsurface disposal. The problem here lies in the lack of a strategy to guide the technology developers in deciding what areas to concentrate their efforts on.

Another problem lies in the lack of priorities for attacking clean-up problems. As discussed in a previous section of this report, it may make most sense, when all factors are considered, not to clean up a particular case of groundwater contamination, even if the technology exists to do so. However, lacking any overall groundwater management strategy for making such decisions, there is a natural tendency for people to take on a problem just because it is there.

A variant on this kind of problem is the situation where it may not be cost-effective to clean up a particular case of groundwater contamination with existing state-of-the-art technology, but where some new, as yet unproved technology holds out great promise of doing the job considerably more effectively and much cheaper. In this sort of situation, it may make sense to merely contain the contamination temporarily, and plan to do the actual clean-up when a viable technology has been developed.

Clearly, the technical people concerned with clean-up and prevention should have a major role to play in these kinds of scenarios, but until overall groundwater management plans are in place, it will be difficult for them to play that role effectively.

Another problem which afflicts nearly every field of endeavour, is the difficulty of establishing cross-discipline ties. Although there has been excellent collaboration between water treatment specialists and hydrogeologists in some cases, in others there still seems to be a compartmentalized approach to the problem. Possibly this is part of the reason why innovative proposals have not received more attention e.g., microbiological groundwater clean-up techniques have been slow in gaining acceptance.

Nevertheless, overall DOE has good reason to be proud of its performance in bringing about this effect.

Recommendation 11 - DOE should maintain its past excellent record in groundwater clean-up and prevention technology while striving for a more interdisciplinary approach and using the strategies and guidelines, when developed, to guide its programs.

Resource Implications

Baseline Program

In view of DOE's excellent record in this area, there is not much that can be added here, other than to encourage the organizations concerned to maintain their past activities.

Personnel from these groups should be closely involved in developing guidelines in various areas, and where guidelines have been developed, in implementing them. Other initiatives, such as the use of the NSERC Industrial Chair program are discussed elsewhere in these Recommendations.

Enriched Program

When guidelines have been developed and groundvater management plans have started to take shape it is likely that one or more topics in the area of clean-up and prevention technology will be clear candidates for significantly increased effort. The National Contaminated Sites Program is providing $50 million over five years for technology development relating to the site clean-up issue. Other candidates for increased effort, such as spill containment technologies could be considered for funding, along with other research programs, if new resources become available.

Additional Resources Required for Enriched Program

Purpose	Py	$
Development of High Priority Clean-up and Prevention Technologies	Included in Element 15	

Model Element 10. State of the Art Technical Options for Groundvater Development are Available to Groundvater Managers.

In certain specialized areas DOE has an excellent knovledge of the most up to date technologies concerned vith vater resources development. These include floods and flood forecasting, hydrometric surveys, hydroelectric energy generation and others. Unfortunately, groundvater is not one of them. To be sure, DOE and other federal departments possess adequate knovledge of conventional geotechnical techniques employed in engineering, but these are not necessarily or even probably state of the art and, in any event, are not concerned with groundvater development but rather with construction.

Perhaps the most glaring deficiency in the federal government's knowledge of what can and cannot be done in developing and making better use of the country's groundwater resources is an almost total ignorance of artificial recharge techniques and conjunctive surface and groundwater development. Other areas relating to groundwater development technology where DOE is seriously deficient include permafrost, instrumentation (both quantitative and qualitative), numerical modelling, geophysics, drilling technology, geochemistry, groundwater microbiology and others. The problem is not so much that DOE lacks these technological skills in-house because many of them are available in industry or the universities. The real problem is that because DOE lacks so many of these skills, it often does not know the right experts to ask or, even worse, does not even know it should be asking a question at all. The causes of this deficiency are primarily historical; they do not reflect any deliberate decisions to play down this aspect of DOE's activities.

If the implementation of the sustainable development program is to succeed with respect to groundwater, the federal government will have to make a much more serious effort to ensure that it has available the best possible groundwater development technology. Whereas it would definitely be advantageous to have the expertise in-house, this would be very expensive (especially in terms of pys) and it is very unlikely that DOE (or any other federal department) would be able to afford the required number of FTC positions in the foreseeable future. However, expertise is available in universities and the private sector, which could be drawn upon provided that Departments have someone on staff who is knowledgeable enough to initiate and manage the appropriate contracts.

The hydrogeologist to be hired by DOE to develop Strategies and Guidelines could also function as the scientific authority for all groundwater development work in DOE, at least on an interim basis. He/she would need some contract funds to operate.

Recommendation 12 - It is recommended that the duties of the hydrogeologist to be hired by DOE (see Recommendation 10) should include responsibility for groundwater development technology. He/she should be provided with a modest budget for this work.

Resource Implications

Baseline Program

Within DOE some readjustment of internal priorities could undoubtedly be made in order to free up some contract funding for this Element. However, any such funding is likely to be very modest, so that the Baseline Program would be essentially office studies, with possibly some small contracts.

Enriched Program

All new technological developments require some kind of field testing in order to demonstrate that the technology is a useful real-world tool. Such field studies are expensive (relative to office work) and would require additional new funding.

Over a five-year period, new resources required are estimated to start at approximately $30,000 in year 2, rising to perhaps $75,000+ in the fifth year depending on how promising the new groundwater development technologies turn out to be.

Additional Resources required for Enriched Program

Purpose	Py	$
To develop and demonstrate new groundwater development technologies.	---	$30,000 (year 2) to $100,000 (year 5)

Model Element 11. Value of Canada's Groundwater Resources is Known

Previous sections of this Report have established that at present essentially nothing is known concerning the value in social, economic and environmental terms of Canada's groundwater resources. It is not even possible to make qualitative statements about its value to society, based on how society deals with groundwater-related issues.

On the one hand, society appears to treat this resource as having essentially no value. Withdrawals are poorly managed, if at all; little consideration is given to the possibility of contaminating groundwater by a host of common practices; we have not bothered to look for new and more efficient ways of utilizing groundwater even in areas where water shortages are imminent. All this would indicate that we do not value the resource very highly.

On the other hand, society appears to be perfectly content to spend (or to force someone else to spend) millions of dollars on clean-up attempts in cases where only a few users are threatened and where replacement water supplies could be provided at a small fraction of the cost of clean-up. This seems to imply that groundwater is a highly valued commodity, to be protected at almost any cost.

These attitudes are obviously inconsistent and they could not co-exist if we had any true appreciation of what our groundwater resources are really worth to us. Most groundwater managers would probably agree that on balance Canada's groundwater resources, like its surface water resources, are seriously undervalued, whatever value system is used as a yard-stick; economic, social or environmental. However, this is only opinion because to date there have been no studies on what the country's groundwater resources are worth. This Effect is another key element of the GRDM because without knowing the value of the resource it is impossible to make any rational decisions concerning either groundwater contamination or groundwater development and groundwater management becomes a pointless and wasteful activity.

It will not be easy to assess the value of groundwater to Canadians for the reasons given on pages 4 to 5. The most effective approach will likely be to start with a general, national overview and then to develop successively more detailed pictures on regional, provincial and local scales. This process will take five years to complete and will need to be updated periodically.

A joint federal/provincial approach is, as usual, by far the most effective way to proceed. Funding for the initial, national overview could justifiably be considered a federal responsibility, but cost sharing would be indicated for the subsequent, more detailed assessments.

Other federal departments such as Agriculture, Energy, Mines and Resources, Health and Welfare could each make significant contributions to various parts of the national overview and to the more detailed assessments and should be included in the federal team.

Recommendation 13 - It is recommended that DOE initiate immediately a study on a national scale to establish the social, economic and environmental value of groundwater to Canadians. This should be followed up by cost-shared provincial, regional and local assessments at a more detailed scale.

Resource Implications

Baseline Program

DOE resources have been provided for 1990/91 for a very general, first-cut evaluation of the value of groundwater to Canada. It is likely that this investigation can be combined with studies required for guideline development for the National Contaminated Sites Program because the value of the groundwater is one of the determinants of whether or not a site should be cleaned up.

Funds for more detailed regional and provincial studies could also probably be found within DOE. However, experience shows that this method of operation, while feasible, leads to extended completion dates. If provinces and other departments are to be involved, as they should be, a more reliable source of funding is required.

Enriched Program

Consequently, it is considered preferable to fund the more detailed studies on a province or region-specific basis, funded by cost-shared agreements under a CWA-type agreement. If twelve provincial and territorial studies were carried out over a five year period at a cost of $25 000 per study shared 50/50 with the provinces the cost would be $30 000 annually.

Additional Resources required for Enriched Program

Purpose	Py	$
Regional Studies of the Value of groundwater	--	$30,000/yr for 5 years

Model Element 12. Value of other Resources at Risk from Contaminated Groundwater is Known.

It was pointed out on pages 4 to 5 that contaminated groundwater poses a threat not just to the direct users of that groundwater but also to users of surface water bodies which may become contaminated by the contaminated groundwater discharging into it. It is suspected that a significant proportion of the contaminants in Lake Ontario got there in this way.

This kind of threat is also very important in BC where the salmon spawning grounds and stream habitats are highly vulnerable to contaminated groundwater from mine workings. The same kind of concern exists with the proposed method of disposing of high level nuclear wastes in a deep underground vault.

In all these cases, the major threat posed by contaminated groundwater is not to direct users of the groundwater, but to users of surface water which has been contaminated by the groundwater. It is believed that this indirect threat posed by contaminated groundwater is of the same order of magnitude as the direct threat to groundwater users.

However, as with the direct threat the magnitude of this indirect threat has not been evaluated in any systematic way so that at present it is impossible to evaluate the actual or potential costs attributable to this cause. It is therefore impossible to establish any rational approach to deal with this problem.

Other federal resource departments such as Fisheries and Oceans should have a major interest in establishing a realistic assessment of this threat and would have to be involved on the federal team. Provinces, as usual would have to be involved as partners and co-sponsors.

It is essential, therefore to establish some way to assess the magnitude of the problem and an approach similar to that for Model Element 11 seems appropriate; namely:

Recommendation 14. It is recommended that, in conjunction with the actions in Recommendation 13, studies of the indirect social, economic and environmental costs of groundwater contamination, should be undertaken in cooperation with the provinces and other federal departments.

Resource Implications

Baseline Program and Enriched Program

Because of their similarity, this Effect and the previous one could well be combined and studied jointly at essentially no increased cost. However, it is important to remember that the two Effects are different and that to consider the one without the other is likely to cause serious mistakes in developing rational groundwater management plans.

Unfortunately, there appears to have been a tendency to neglect the indirect aspect of groundwater contamination, which is why it has been identified separately in this Report.

Additional Resources required for Enriched Program

Purpose	Py	$
Detailed evaluation of resources at risk from contaminated groundvater	Nil (alloved for in Element 11)	Nil

Model Element 13. Present and Future Demands for Groundvater are Established.

This Element deals with the development aspect of the social/economic/environmental side of groundvater management and is complementary to Elements 11 and 12.

Although present demands for groundwater can be (and have been) estimated from records of consumption, future demands cannot be estimated in any rational way without introducing the notion of water pricing. Without knowing what price consumers will be asked to pay for their water supply, it is not possible to assess what the overall demand for water will be, nor to estimate what proportion of that total demand could be supplied by groundwater. Without some pricing mechanism, it is not feasible to determine whether some new technology (such as artificial recharge) will be able to augment existing supplies economically, or whether some existing consumer practices might become uneconomic and hence, cease.

Therefore, this Model Element implicitly requires that a pricing structure for groundwater be established. At present there is nothing resembling a free market place for water and it is not likely that one will be developed in the next decade or so, so that establishing a pricing structure for groundwater cannot rely on free-market concepts. Instead, reliance will have to be placed on the work done in Model Element 11 on establishing the value of groundwater to be able to assess future demands on the resource.

This may require some innovative economic science. However, the concern with pricing applies just as much to surface water as to groundwater, so that whatever economic approaches are developed for the one will apply to the other and costs will thereby be minimized.

Among other federal departments with a major interest in this issue, Agriculture Canada is probably the most important because of agriculture's crucial dependence on adequate water supplies. Agriculture Canada should play a major role in achieving this Effect.

Provinces have a primary role, but as with Elements 11 and 12 a national overview of groundwater pricing could legitimately be considered to be a federal initiative (as was the Report on Groundwater Use), with provincial involvement and cost sharing coming in at the subsequent regional, provincial and local levels of detail.

Recommendation 15 - Immediately after the study on the value of groundwater in Element 11 DOE should initiate a national overview on future demands for groundwater which should be followed up by joint, cost shared, federal provincial studies at the regional, provincial and local levels of detail.

Resource Implications

Baseline Program

This Element is the natural follow-up to the activities in Elements 11 and 12 and should take over from them without interruption.

As the national overviews of Elements 11 and 12 will take a year to complete, work on this element should begin only in the second year of the five year program. Once again, in-house resources can probably be found to take care of the national overview, but specifically targeted, new resources will be required for the detailed regional/provincial studies.

Enriched Program

As most of the fundamental economic problems will have been tackled by activities in Elements 12 and 13, the cost/province of establishing groundwater demand should be somewhat less than for establishing its value.

Additional Resources Required for the Enriched Program

Purpose	Py	$
Establishing demands for groundwater on a Regional basis	--	$20,000/yr starting in year 2.

EFFECTS - SCIENCE/DATA

Model Element 14. Up-to-Date Groundwater Knowledge and Expertise is Available to Groundwater Managers

It is difficult, if not impossible, to assess in an objective way whether or not this effect is being adequately achieved. In many respects Canada appears to be adequately served by its groundwater professionals; for example, Canada does not appear to be technically backward in dealing with U.S. agencies on international groundwater issues, apart from sheer numbers of people. However, there are some disturbing signs that we may be in danger of falling behind. For example, DOE at one time possessed a major proportion of the expertise familiar with the hydrogeological aspects of high level nuclear waste disposal. Yet, when AECL's concept assessment was presented for review in the fall of 1989 DOE was hard pressed to mobilize enough groundwater expertise and knowledge to review the documents. There are many reasons why this happened but two of the more important are:

- an overall shortage of groundwater expertise in DOE - our high level nuclear waste groundwater experts are also our pesticide experts, landfill experts, mining experts, etc. so that if they work on one problem, others suffer; and

- lack of effective mechanisms whereby the knowledge and expertise, which by and large resides in DOE's two water Research Institutes, can be transferred to operational managers.

It may be that DOE is now in a transition stage with regard to groundwater. Regions are just starting to hire their own hydrogeologists; outside the Institutes, DOE Headquarters has only one expert hydrogeologist and no operational groundwater specialists. A large part of the problem, then, seems to be that at present there is a serious shortage of operational hydrogeologists who can apply both existing and new knowledge to real world problems.

With regard to other Departments, discussions with departmental officials indicate that there are extensive overlaps of scientific interest in groundwater between DOE and both Agriculture Canada (agricultural chemicals, groundwater supplies) and Energy, Mines and Resources (permafrost, water supply, (mine) waste disposal). There are extensive opportunities for undertaking joint hydrogeological research in a wide variety of areas of mutual interest which would undoubtedly result in substantially reduced overall costs. Although Agriculture and EMR are probably the departments with the closest interests to DOE's, other departments would no doubt be interested in joint ventures in more limited areas.

The potential for joint research with both Agriculture and EMR is of sufficient magnitude and mutual benefit that formal agreements should be entered into between DOE and these two departments at a senior departmental level. Although bench scientists are already collaborating extensively (mostly with Agriculture Canada), it should not be left entirely to individual scientists to establish the kind and extent of the interdepartmental co-operative research the department wants to engage in.

The potential benefits of developing closer ties with the academic community were outlined on pages 41 to 46 and possible mechanisms for doing so were discussed. For a relatively modest investment, a very significant improvement in DOE's access to the country's best hydrogeological talent would be obtained, together with the prospect of substantially increasing the numbers of trained hydrogeologists in the job market place. Although some useful actions could be taken without increases in resources, it must be recognized that the major payoffs cannot be achieved without some resource increases, although these may not necessarily be substantial.

Recommendation 16 - It is recommended that the overall adequacy of DOE's capability to undertake operational groundwater work including environmental assessments be reviewed, together with a review of the adequacy of existing technology transfer mechanisms between research and operational components of the Department. This review should be completed in one year.

Recommendation 17 - It is recommended that 25 PYs and $1.25 million new resources be allocated to RD and D activities in DOE.

Recommendation 18 - It is recommended that DOE should approach Agriculture Canada and Energy Mines and Resources at a senior official level with a view to entering into formal agreements for joint research on groundwater topics of mutual interest. Similar agreements should be negotiated with other departments.

Recommendation 19 - It is recommended that DOE should endorse the concept of establishing an Industrial Chair in Groundwater at a Canadian university and/or a viable groundwater program at one university in each of DOE's five Regions. DOE should agree to assist in the establishment of these positions to some suitable level ($200,000 per year suggested). DOE should assist candidate Universities in seeking industrial sponsors.

Recommendation 20 - It is recommended that DOE establish a fund for the support of extra-mural groundwater research, similar to the former WRRSP.

Resource Implications

Baseline Program

The internal DOE reviews can be carried out using existing resources.

With regard to improving DOE's contacts with universities, there are some initiatives that can be taken without significant new resources.

One such initiative involves the "posting" of DOE research staff to the faculty of universities as described in a previous Section. There will certainly be both advantages and disadvantages in doing this, so that further discussions and/or negotiations with the universities will be necessary before deciding to go ahead. Nevertheless, any such move would have the basic advantage of not costing any new PYs and only relatively insignificant dollars.

The establishment of groundwater faculty positions could also result in little or no cost increases to the Department, if 100 per cent external sponsorship could be found. However, it appears more likely that this approach would have a better chance of succeeding if some departmental resources were committed to it.

Enriched Program

There are several possible components to an enriched research program any or all of which offer significant rewards:

1) DOE groundwater research and development programs could be enlarged by up to about 15-25 py in a staged fashion. This limit is suggested because:

   a) it is unlikely that a greater increase could be effectively managed;

   b) resource increases in other, non R and D areas would be required to effectively absorb and use the new knowledge and expertise; and

   c) hydrogeological specialists are in very short supply and qualified candidates probably could not be found to fill more than this number of positions.

Any increase in resources for DOE's two water research Institutes would have to be judged in the context of resources being allocated to the two Technology Centres (WTC and RRETC) as well.

2) DOE could proceed with establishing university faculty positions either under the NSERC program or independently, and its chances of succeeding would be greatly enhanced if DOE put up some sponsorship money ($200,000 is suggested).

3) A program to support groundwater related research (including site remediation) at universities and in the private sector could be initiated. A figure of $1.25 million is proposed.

Additional Resources for Enriched Program

Purpose	PY	$
Groundwater Research	25 (over 5 yrs)	$1,250,000*
Sponsorship of University Faculty Positions	--	$ 200,000
Research support program	--	$1,250,000

Model Element 15. Efficient Federal Provincial Groundwater Data Banks are Established

On pages 27-28, it was indicated that one of the major impediments to rational groundwater management in Canada was the lack of organized groundwater data bases focusing on groundwater management needs. It was suggested that a joint federal/provincial approach be adopted to develop nationally compatible groundwater data banks conditional on provinces simultaneously developing rational groundwater management strategies in their jurisdictions. It was also suggested that the Canada Water Act would be an appropriate funding mechanism.

A start on developing nationally compatible groundwater data banks has already been made at a recent federal/provincial workshop in Saskatoon; this is to be followed by another workshop in the fall of 1990 at which DOE will present concrete proposals on how to put nationally compatible data banks in place.

An important consideration which must be borne in mind is that these data banks will have to be capable of dealing with both traditional resource management data and data generated in the course of site remediation investigations and post-clean-up monitoring.

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* PY and $ totals include resources for both IWD Institutes and EP Technology Centres.

Recommendation 21 - It is recommended that DOE establish cost shared agreements with the provinces to develop nationally compatible, efficient groundwater data banks, conditional on the provinces establishing rational groundwater management strategies.

Resource Implications

Baseline Program

Work can be and has been started on identifying what the specific requirements are and how they should be tackled. The Workshop in Saskatoon was financed from existing federal and provincial budgets and the follow-up Workshop planned for the fall of 1990 will be funded in the same way. It is probable that the Fall Workshop will identify specific problems and tasks which can be undertaken without any new resources. Such tasks might include the development of standard methodologies for storing/retrieving lithological and other data, well locations, etc.

Enriched Program

If it turns out that extensive systems analysis/program development work is required, then either additional py or, most probably, additional dollar support would be required.

DOE has included 1 py and $20K in its 1990-91 LTOP, but this will not be enough if large-scale program development is required. In the latter case, support from CWA would be solicited.

Additional resources required for Enriched Program

Purpose	PY	$
Systems analysis	1	20,000
Program development	-	100,000
TOTALS	1	120,000

Model Element 16. Adequate Groundwater Data are Available

At present there is no reason to believe that lack of data is an obstacle hindering the development and operation of rational groundwater management strategies. The problem now appears to be that existing data are poorly organized for management purposes. Provinces seem to be reasonably content, in general, with the mechanisms they have set up to ensure that they obtain the data being generated by well drillers, water quality laboratories, etc.

Therefore, it appears that this Effect is one which, in large measure has already been achieved and continues to be achieved. As mentioned on page 28, action is required to organize groundwater data banks more effectively, but the data collection process appears to be functioning well. Groundwater data collection has always been regarded as a provincial function and it should continue to be regarded in this light, with one proviso. The relative importance of groundwater and surface water use* varies greatly from province to province (88% groundwater in PEI to 2% groundwater in Ontario). Some provinces where groundwater use is high have taken the position that there is no fundamental conceptual difference between monitoring groundwater and monitoring surface water and because groundwater is so important to their province, they would like to be able to negotiate agreements for data collection which include groundwater. DOE has generally rejected this kind of proposal on the grounds that groundwater monitoring would be very expensive.

However, the provincial position is not unreasonable and in fact in some Regions IWD does collect groundwater hydrographic data.

Recommendation 22 - It is recommended that DOE establish a working group to review its present policies concerning the collection of groundwater data and report on its findings in one year.

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* Total water use including thermal water use.

Resource Implications

Baseline Program and Enriched Program

No reallocations or new resources are required for this recommendation.

Model Element 17. Up-to-Date Socio-Economic Knowledge and Expertise on Groundwater are Available to Groundwater Managers

Throughout this report, social and economic considerations appear repeatedly as being major factors in the groundwater issue. They are just as important as the natural science and engineering factors which traditionally are what is thought of when groundwater management is under consideration.

But natural science and engineering by themselves are not enough to ensure that groundwater and, indeed, any other natural resource is managed effectively. The groundwater issue under discussion in this report is one of the best illustrations of this fact.

Although there have been problems with the way the department has attempted to deal with the groundwater issue, fundamentally they have not arisen from major deficiencies in the department's natural science and engineering capabilities.

Time and again throughout this Report it is evident that if we had got our basic socio-economic approach right, then the scientific and engineering problems would have been relatively straightforward even though the Department does lack certain important scientific/technical capabilities. As matters now stand, it appears that little progress will be made towards managing Canada's groundwater effectively until those socio-economic problems are resolved.

However, the Report also shows that groundwater poses some special and unusually intractable problems; for example, when we attempt to place a value on groundwater. It is not evident that DOE possesses or has access to the right economic tools to perform this kind of analysis; they may not even exist.

Therefore, what is needed is some socio-economic analog to Model Element 14 which in essence is the world of DOE's two natural science research Institutes. At present, DOE does not contain any organization charged with performing socio-economic research on water. Although some of the work performed in IWD/HQ Water Planning and Management Branch comes close to being socio-economic water resources research, it is not officially recognized as such. In any event it comprises only half a dozen pys compared with several hundred pys devoted to natural science water research in DOE.

Consequently, the presumption is strong that DOE is deficient in its access to adequate socio-economic groundwater resources knovledge.

It is beyond the scope of this report to consider what might be done about this situation. Nevertheless it is felt justified to make the following recommendation:

Recommendation 23 - It is recommended that DOE review the adequacy of its own internal expertise and knowledge in the area of the socio-economic aspects of groundvater resources and also the extent to which any deficiencies identified could be remedied through arrangements with universities and the private sector.

Resource Implications

Baseline Program

The recommended in-house review would be undertaken using existing resources.

Enriched Program

The amount of additional resources which would be required for an enriched socio-economic groundwater research program would depend on the outcome of the proposed review.

EFFECTS - COMMUNICATIONS

Model Element 18. Canadians Receive Information on Groundwater Management, Protection and Development

A perennial problem with publicizing groundwater and groundwater issues is that it is the hidden resource; all the "action" happens underground. This makes it difficult for the public to relate to and understand-much more so than for surface water where everything is visible and accessible. Spill a toxic chemical in a river and the dead fish are on the beach tomorrow. Spill that same toxic chemical on the ground and it may take decades for anything visible to happen. This is not the kind of thing out of which hot news items are made!

One of the consequences of the invisibility of groundwater is that there are a lot of popular misconceptions about how it occurs and what processes take place.

For example, one very common myth is that groundwater occurs as underground rivers and lakes. Whereas underground rivers do occur in very special, unusual conditions, by far the greatest volume of groundwater of significance to man occurs in porous media like sands and gravels or in fractured rocks such as limestones and sandstones.

Another common misconception is that once something gets into groundvater it will stay there for ever unless someone deliberately pumps the groundvater back up again. In fact, "what goes down, must come up", and although this catch-phrase is something of a simplification (e.g., it takes no account of sorption processes), it is much closer to reality than prevailing popular opinion.

These and other erroneous or distorted popular impressions about what groundvater is and how it behaves make it difficult for groundvater managers to "sell" the public on what is required in order to manage the resource effectively.

In recent years, both DOE and provincial agencies have taken a more active role in attempting to provide the public with accurate, factual, non-partisan information on a wide variety of water resources topics, including groundwater, using many formats, such as Fact Sheets, Brochures, Videos, etc. Non-governmental organizations, such as the Girl Guides, have started to prepare their own Fact Sheets[39] and other information on groundwater for the benefit of their members and the general public.

All these developments cannot do anything but good for the public's awareness of the real groundwater issues and such public information efforts should be maintained and intensified. Because of its "visibility" problems, groundwater should be given particular attention.

Recommendation 24 - It is recommended that DOE in its ongoing public water information programs should place more emphasis on groundwater because of its "visibility" problem compared with other water resources issues.

Resource Implications

Baseline Program

Existing water resource public information and education programs can be "fine-tuned" to give more prominence to groundwater without requiring additional resources. This is already happening.

Enriched Program

Some of the more effective public education tools such as TV clips, video and film shorts are expensive to produce and will require additional funding. One twenty minute video on groundwater would cost about $45,000. Resources are requested for one such item per year (or equivalent) plus resources to cover the production of more conventional public awareness material such as fact sheets, etc.

Additional Resources Required for Enriched Program

Purpose	PY	$
Groundwater videos, films	NIL	$45,000

TABLE 5

SUMMARY OF RESOURCE REQUIREMENTS
FOR ENRICHED PROGRAM

RECDN.	SUBJECT	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5	
		py	K$	py	K$	py	K$	py	K$	py	K$
3,4	Coordn., Working Gp. Secretariat	2	150	2	150	2	150	2	150	2	150
8	Operational Groundwater Activities	10	500	20	1000	25	1250	25	1250	25	1250
9,10	Guidelines (National)	1	100	1	150	1	150	1	150	1	150
12	Groundwater Development Technology	-	-	-	30	-	50	-	80	-	100
13,14	Socio-Econ. Value Studies	-	30	-	30	-	30	-	30	-	30
15	Groundwater Demand Studies	-	-	-	20	-	20	-	20	-	20
17,11	RD&D	5	270	10	500	15	750	20	1000	25	1250
19	Sponsored University Faculty	-	200	-	200	-	200	-	200	-	200
20	Research Subventions	-	1250	-	1250	-	1250	-	1250	-	1250
21	Data Banks	1	120	1	120	1	120	1	120	1	120
24	Public Info/Educn.	-	45	-	45	-	45	-	45	-	45
	TOTALS	19	2665	34	3495	64	4015	49	4295	54	4565

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